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FEASIBILITY STUDY FOR OPERABLE UNIT 2 (OU 2) VOLUME 1 OF 2 NAS PENSACOLA FL
04/26/1999
ENSAFE, INC

FEASIBILITY STUDY REPORT
OPERABLE UNIT 2
NAS PENSACOLA
PENSACOLA, FLORIDA

SOUTHNAVFACENGCOM
CONTRACT NO.: N62467-89-D0318
CTO-059

Volume I
Sections 1 through 10

Prepared for:

Department of the Navy
Southern Division
Naval Facilities Engineering Command
North Charleston, South Carolina

Prepared by:

EnSafe Inc.
5724 Summer Trees Drive
Memphis, Tennessee 38134
(901) 372-7962

April 26, 1999

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The Contractor, EnSafe/Allen & Hoshall, hereby certifies that, to the best of its knowledge and belief, the technical data delivered herewith under Contract No. N62467-89-D-0318 is complete, accurate, and complies with all requirements of the contract.

Date:	**April 26, 1999**
Signature:	Allison Harris
Name:	**Allison Harris**
Title:	**Task Order Manager**

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ACRONYMS

$\mu g/L$	micrograms per liter
$\mu g/kg$	micrograms per kilogram
1,2-DCA	1,2-dichloroethane
1,2-DCE	1,2-dichloroethene, 1,2-dichloroethylene
ACLs	Alternate Concentration Limits
ARARs	Applicable or Relevant and Appropriate Requirements
BEHP	Bis(2-ethylhexyl)phthalate
BEQs	Benzo(a)pyrene equivalents
bgs	below ground surface
BRA	Baseline Risk Assessment
BTEX	Benzene, toluene, ethylbenzene, and xylene
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
CGs	Cleanup Goals
CLEAN	Comprehensive LongTerm Environmental Action Navy
CLP	Contract Laboratory Program
cm/sec	centimeter per second
COCs	Contaminant of Concern
COPCs	Contaminant of Potential Concern
CWA	Clean Water Act
CY	Cubic Yard
DRMO	Defense Reutilization and Marketing Office
E/A&H	EnSafe/Allen & Hoshall
E&E	Ecology & Environment
FS	Feasibility study
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FGGC	Florida Groundwater Guidance Concentration
FOTW	Federally Owned Treatment Works
FPDWS	Florida Primary Drinking Water Standard
FSDWS	Florida Secondary Drinking Water Standard
FSWQ	Freshwater Surface Water Quality Criteria
ft^2	square feet
G&M	Geraghty & Miller, Inc.

HDPE	High density polyethylene
IAS	Initial Assessment Study
IRP	Installation Restoration Program
ISCTLs	Industrial Soil Cleanup Target Levels
IWTP	Industrial Wastewater Treatment Plant
LUCA	Land Use Restriction Agreement
MCLGs	Maximum Contaminant Level Goals
MCLs	Maximum Contaminant Levels
MEK	Methyl ethyl ketone
mg/kg	milligrams per kilogram
MNA	Monitored natural attenuation
msl	mean sea level
MSWQ	Marine surfacewater quality criteria
NADEP	Naval Aviation Depot
NAS	Naval Air Station
NCP	National Oil and Hazardous Substances Contingency Plan
NEESA	Naval Environmental and Engineering Support Activity
NFESC	Naval Facilities Engineering Service Center
O&M	Operations & maintenance
OSWER	Office of Solid Waste and Emergency Response
OU 2	Operable Unit 2 (Sites 11, 12, 25, 26, 27, and 30)
PAHs	Polynuclear Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyl
PCE	Tetrachloroethene, tetrachloroethylene
PQG	Poor quality groundwater
PRB	Permeable reactive barrier
PRGs	Preliminary remediation goals
PWC	Public Works Center
RAOs	Remedial Action Objectives
RASO	Radiological Affairs Support Office
RBCs	Risk Based Criteria
RCRA	Resource Conservation and Recovery Act
RCs	Reference concentrations
RD	Remedial design
RGs	Remedial goals
RI	Remedial Investigation
ROD	Record of Decision

RSCTLs	Residential Soil Cleanup Target Levels
SCTLs	Soil Cleanup Target Levels
SDWA	Safe Drinking Water Act
SEGS	Southeastern Geological Society
SL-PQG	Soil leaching criteria protective of poor quality groundwater
SL-SW	Soil leaching criteria protective of surface water
SMCLs	Secondary Maximum Contaminant Levels
SQAG	Sediment quality assessment values
SSLs	Soil Screening Levels
SSVs	Sediment Screening values
SVE	Soil vapor extraction
SVOCs	Semivolatile organic compounds
TCE	Trichloroethene, trichloroethylene
TCLP	Toxicity Characteristic Leaching Procedure
TELs	Threshold effect levels
USDOT	U.S. Department of Transportation
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	Underground storage tank
VOCs	Volatile organic compounds
yd^2	Square yard

GROUNDWATER ELEVATION DATA FOR SHALLOW GROUNDWATER MONITORING WELLS

Well ID	Northing	Easting	Top of Casing Elevation	Depth to Groundwater	Groundwater Elevation
11GS01	505776.7	1094687	9.89	7.12	2.77
11GS03	506281.0	1094747	11.21	8.22	2.99
11GS05	506678.6	1094783	10.34	6.30	4.04
11GS07	506427.8	1095313	6.28	3.86	2.42
11GS09	505933.7	1095164	5.01	2.89	2.12
11GS11	505571.8	1095066	6.28	5.55	0.73
11GS13	505372.3	1094893	5.48	4.06	1.42
12GS01	506729.3	1094483	17.81	14.24	3.57
12GS02	506554.9	1094487	18.23	14.81	3.42
12GS03	506573.1	1094323	18.23	14.91	3.32
12GS05	506400.6	1094497	18.21	14.69	3.52
12GS06	506280.5	1094500	18.22	14.76	3.46
12GS08	506076.3	1094338	18.34	14.42	3.92
12GS09	506077.7	1094480	16.85	13.25	3.60
12GS10	505929.0	1094496	17.04	13.31	3.73
12GS13	505810.1	1094511	16.64	12.96	3.68
12GS14	505676.1	1094507	16.96	13.34	3.62
12GS15	505696.0	1094369	17.17	13.04	4.13
12GS16	505869.5	1094509	17.03	13.29	3.74
25GS01	505618.4	1094070	26.24	20.92	5.32
25GS02	505507.7	1093577	24.74	17.10	7.64
25GS03	505249.3	1093797	20.23	13.51	6.72
25GS07	505485.1	1093754	23.60	16.69	6.91
25GS08	505302.0	1093825	21.01	14.43	6.58
25GS09	505216.8	1093933	19.18	13.32	5.86
26GS02	506241.0	1094702	18.05	14.77	3.28
26GS03	506174.3	1094621	18.68	15.60	3.08
26GS04	506141.6	1094702	19.64	16.47	3.17
27GS01	505194.4	1093209	26.06	16.55	9.51
27GS02	505356.3	1093208	27.71	18.20	9.51
27GS03	504991.8	1093370	27.22	18.55	8.67
27GS04	505072.7	1093673	22.51	15.31	7.20
27GS05	504895.6	1093736	23.90	17.31	6.59
27GS06	504878.2	1093599	24.18	16.99	7.19
27GS08	505044.9	1093547	25.28	17.45	7.83
27GS09	505127.2	1093559	25.07	17.21	7.86
27GS10	504847.9	1093333	25.47	16.84	8.63
27GS11	504983.7	1093275	27.16	18.04	9.12
27GS12	505299.4	1093602	24.39	16.73	7.66
27GS14	505238.3	1093399	25.06	16.52	8.54
27GS15	505247.8	1093427	24.80	16.38	8.42
27GS16	505188.6	1093343	25.40	16.50	8.90
27GS17	505197.6	1093369	25.36	16.63	8.73
27GS18	505202.2	1093410	25.32	16.79	8.53
27GS19	505210.0	1093471	25.40	17.16	8.24
27GS20	505159.5	1093393	25.39	16.77	8.62
27GS21	505160.5	1093448	25.27	16.97	8.30

GROUNDWATER ELEVATION DATA FOR SHALLOW GROUNDWATER MONITORING WELLS

Well ID	Northing	Easting	Top of Casing Elevation	Depth to Groundwater	Groundwater Elevation
30GS05	504475.9	1093488	20.32	13.96	6.36
30GS06	504711.9	1092835	26.57	15.42	11.15
30GS101	505758.9	1095699	8.28	6.14	2.14
30GS105	505199.5	1094971	7.04	5.35	1.69
30GS108	504983.7	1094741	7.83	6.74	1.09
30GS11	504900.5	1092785	27.96	16.49	11.47
30GS113	504380.8	1094483	9.20	7.95	1.25
30GS12	504903.6	1092692	29.05	17.18	11.87
30GS123	503948.8	1094259	8.87	6.84	2.03
30GS146	504675.3	1094194	25.42	22.48	2.94
30GS15	505502.9	1092768	31.50	20.83	10.67
30GS157	504793.0	1094348	30.77	18.18	12.59
30GS162	504644.6	1093970	24.93	20.66	4.27
30GS164	504672.0	1093916	24.40	19.78	4.62
30GS165	504718.8	1093937	24.29	19.74	4.55
30GS166	504685.0	1093998	25.29	21.15	4.14
30GS168	504557.6	1093737	23.66	17.88	5.78
30GS169	504557.6	1093706	24.53	17.95	6.58
30GS18	504554.0	1093322	16.65	8.40	8.25
30GS20	504409.1	1093419	18.88	12.24	6.64
30GS22	505001.8	1093023	28.83	18.46	10.37
30GS23	505017.8	1093062	26.16	17.02	9.14
30GS24	505060.5	1093154	26.37	16.72	9.65
30GS25	505002.2	1093114	26.94	17.14	9.80
30GS26	504993.2	1093171	27.23	17.87	9.36
30GS27	504941.6	1093193	26.88	17.57	9.31
30GS28	504885.6	1093213	27.02	17.71	9.31
30GS31	504808.5	1092950	28.10	17.28	10.82
30GS32A	504815.1	1092974	27.92	17.31	10.61
30GS33	504782.8	1092980	27.49	17.22	10.27
30GS37	505185.5	1092972	26.41	17.03	9.38
30GS39	505155.6	1092762	30.05	18.84	11.21
30GS43	505206.2	1092804	32.36	19.35	13.01
30GS45	505420.6	1092913	28.17	17.81	10.36
30GS46	505434.4	1092954	27.93	17.79	10.14
30GS49	505429.4	1093008	27.56	17.62	9.94
30GS50	505360.5	1093034	27.76	17.58	10.18
30GS51	505451.1	1093080	26.34	16.62	9.72
30GS52	505369.5	1093112	26.37	16.59	9.78
30GS55	504987.4	1093050	26.42	17.12	9.30
30GS56	504989.6	1093114	26.39	17.41	8.98
30GS59	505246.3	1092658	26.88	15.36	11.52
30GS61	505065.0	1092616	27.81	15.78	12.03
30GS62	504271.8	1092725	22.87	11.70	11.17

LEGEND

SITE 27 SITE LOCATION
—S— SITE 36
SURFACE WATER BODY
CLOSED LAGOON
743 BUILDING
FENCE LINE
ROADS
SIDEWALKS
GROUNDWATER MONITORING WELL
—1— EQUIPOTENTIAL LINE
— —1— — ESTIMATED EQUIPOTENTIAL LINE
HORIZONTAL GRADIENT LINE

NOTES

1. ONLY GROUNDWATER ELEVATIONAL DATA FROM SHALLOW GROUNDWATER MONITORING WELLS WERE USED TO DEVELOP EQUIPOTENTIAL LINES.
2. ONE FOOT CONTOUR INTERVAL.
3. GROUNDWATER ELEVATION DATA AND CORRESPONDING WELLS SHOWN ON THE FIGURE (IN GREEN) WERE USED TO DEVELOP EQUIPOTENTIAL LINES. DUE TO AQUIFER HETEROGENEITIES, GROUNDWATER ELEVATIONAL DATA FROM WELLS SCREENED BACK ON THE FIGURE WERE NOT USED TO DEVELOP EQUIPOTENTIAL LINES.
4. EQUIPOTENTIAL LINES SHOWN PROVIDE A GENERALIZED GROUNDWATER FLOW MAP BASED ON THE SELECTED DATA SET.

DRAFT FEASIBILITY STUDY
OPERABLE UNIT 2
NAS PENSACOLA
PENSACOLA, FLORIDA

FIGURE 1–5
OU 2 SHALLOW POTENTIOMETRIC SURFACE

Dr by: K. BRONSON	Proj. Code: 0059–00037	
Ck by: JPG	App by: H. BEIRO	Sheet 1
Date: 04/22/99	DWG Name: 0970S008	Of 1

EXECUTIVE SUMMARY
OPERABLE UNIT 2

A feasibility study (FS) was conducted for Operable Unit 2 (OU 2) at Naval Air Station (NAS) Pensacola. OU 2 comprises six sites: Site 11, the North Chevalier Field Disposal Area; Site 12, the Scrap Bins; Site 25, the Radium Spill Area, Site 26, the Supply Department Outside Storage Area; Site 27, the Radium Dial Shop; and Site 30, the Building 649 Complex. The FS reviewed site contamination summaries presented in the remedial investigation (RI) and applicable or relevant and appropriate requirements (ARARs). These data were used to establish remediation goals (RGs) for OU 2 and to develop remedial alternatives appropriate to the contamination present at each site. In accordance with the Navy's future site management plans, soil contamination was reviewed separately for each site. Groundwater contamination was reviewed for Sites 11, 12, and 26 due to proximity and similar contaminants; an identical approach was used for Sites 25, 27, and 30.

State of Florida Soil Cleanup Target Levels (SCTLs) presented in Proposed Rule 62-777 were identified as relevant and appropriate to remedial actions onsite. A review of site contamination, as well as land use considerations, resulted in the selection of industrial standards as RGs. All soil alternatives (except no-action alternatives) include provisions for institutional controls, which will ensure long-term site use remains industrial. Subsurface soil was reviewed and compared against leaching criteria presented in Proposed Rule 62-777, but no continuous subsurface source mass was identified; no remediation goals were developed for subsurface soil. Similarly, an ARAR review identified poor quality groundwater criteria (also presented in Proposed Rule 62-777) as relevant and appropriate to groundwater actions at OU 2.

Soil Evaluations

Site 11 soil exceeded industrial RGs at four locations for one or more of the following contaminants: arsenic, chromium, or polynuclear aromatic hydrocarbons (PAHs). One location sampled during the Site 30 investigation is adjacent to Site 11 and contained similar contaminants; this sample has been included in the Site 11 evaluation. The impacted locations do not represent a single, continuous impacted area; volumes were calculated assuming discrete, localized contamination. The total impacted soil volume considered during the FS is 4,140 cubic yards (CY). Five alternatives were considered for Site 11: no action, institutional controls, soil cover, plant-enhanced bioremediation, and excavation/offsite disposal. Of these, the soil cover, bioremediation, and excavation and offsite disposal alternatives were deemed protective as they met RGs by eliminating risk pathways, treating contaminated soil, or removing contaminated soil from the site. Plant-enhanced bioremediation is considered an innovative technology and would require significant testing and scale-up.

Site 12 soil exceeded industrial RGs at six locations for either polychlorinated biphenyls (PCBs) or PAHs. Of these, there is no direct exposure pathway at four locations because samples were collected beneath concrete pavement. Assuming future uses are similar to current site activities, paved areas will likely remain paved. The two remaining locations are adjacent to each other and may represent continuous surface soil contamination. Therefore, the total impacted soil volume considered at Site 12 during the FS is 330 CY, calculated from the two exposed locations. Importantly, these locations are immediately north of radium contamination which will be addressed by the Radiological Affairs Support Office (RASO); remediation activities were evaluated assuming future site activities for radium removal. Four alternatives were considered for Site 12: no action, institutional controls, soil cover, and excavation/offsite disposal. Of these, the soil cover and excavation and offsite disposal alternatives were deemed protective as they met RGs by eliminating risk pathways or removing contaminated soil from the site.

Site 25 soil exceeded industrial RGs at four locations for at least one of the following contaminants: arsenic, lead, or PAHs. Of these, one location was excavated and disposed of offsite during interim removal actions in 1998. The remaining three locations flank the area addressed by the removal action and therefore were evaluated as two discrete soil contamination areas (north and south of the interim removal action). Therefore, the total impacted soil volume considered at Site 25 during the FS is 180 CY, calculated from the three remaining locations. Four alternatives were considered for Site 25: no action, institutional controls, soil cover, and excavation/offsite disposal. Of these, the soil cover and excavation and offsite disposal alternatives were deemed protective as they met RGs by eliminating risk pathways or removing contaminated soil from the site.

The RI recommended no further action for soil at Site 26; no remedial actions are evaluated for Site 26 in this FS.

Site 27 soil exceeded industrial RGs at eight locations for one or more of the following contaminants: arsenic, lead, dieldrin, or PAHs. Of these, there is no direct exposure pathway at two locations because samples were collected beneath concrete pavement. Assuming future uses are similar to current site activities, paved areas will likely remain paved. One sample was collocated with radium contamination. The impacted locations do not represent a single, continuous impacted area; volumes were calculated assuming discrete, localized contamination. Therefore, the total impacted soil volume considered at Site 27 during the FS is 1,210 CY, calculated from the five exposed locations. Radium contamination will be addressed by RASO; remediation activities were evaluated assuming future site activities for radium removal. Four alternatives were considered for Site 27: no action, institutional controls, soil cover, and excavation/offsite disposal. Of these, the soil cover and excavation and offsite disposal alternatives were deemed protective as they met RGs by eliminating risk pathways or removing contaminated soil from the site.

Site 30 soil exceeded industrial RGs at four locations for either arsenic. PCBs, or PAHs. One location sampled during the Site 30 investigation is adjacent to Site 11 and contained similar contaminants; this sample has been included in the Site 11 evaluation. The three remaining impacted locations are concentrated immediately south of Farrar Road across from the Building 649 complex. Two locations may represent a single, continuous PAH-impacted area; the third location was characterized by PCBs and is in a grassy median. Volumes were calculated assuming discrete, localized contamination. The total impacted soil volume considered during the FS is 1,840 CY. Five alternatives were considered for Site 30: no action, institutional controls, soil cover, plant-enhanced bioremediation, and excavation/offsite disposal. Of these, the soil cover, bioremediation, and excavation and offsite disposal alternatives were deemed protective as they met RGs by eliminating risk pathways, treating contaminated soil, or removing contaminated soil from the site. Plant-enhanced bioremediation is considered an innovative technology and would require significant testing and scale-up (i.e., pilot-testing.)

Groundwater Evaluations

Sites 11, 12, and 26 shared common groundwater contaminants, including antimony, cadmium, chromium, lead, silver, cis-1,2-dichloroethylene, 1,1,2,2-tetrachloroethane, trichloroethylene, and vinyl chloride. Site 11, 12, and 26's total impacted groundwater volume considered during this FS, 4.6 million gallons, was calculated from three distinct areas of concern. Five alternatives were considered for groundwater at Sites 11, 12, and 26: no action; monitored natural attenuation (MNA); phytoremediation; groundwater extraction/discharge to the Federally owned treatment works (FOTW) on base; and extraction, pretreatment, and discharge to the FOTW. Of the five alternatives considered, only the no action alternative does not provide some degree of protection in areas exceeding RGs. The phytoremediation alternative is innovative and would require significant testing and scale-up before implementation.

Sites 25, 27, and 30 shared common groundwater contaminants, including cadmium, chromium, lead, heptachlor epoxide, bis(2-ethylhexyl) phthalate, naphthalene, benzene, chloroethane, chloroform, 1,3-dichlorobenzene, 1,1,-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethene, tetrachloroethylene, 1,1,1-trichloroethane, trichloroethylene, and vinyl chloride. Site 25, 27, and 30's total impacted groundwater volume considered during the FS, 31.1 million gallons, was calculated from seven distinct areas of concern. Six alternatives were considered for groundwater at Sites 25, 27, and 30: no action; MNA; phytoremediation; permeable reactive barriers (PRBs); groundwater extraction/discharge to the FOTW; and extraction, pretreatment, and discharge to the FOTW. Of the six alternatives considered, only the no action alternative does not provide some degree of protection in areas exceeding RGs. PRB and phytoremediation alternatives are innovative and would require significant testing and scale-up before implementation.

1.0 INTRODUCTION

The purpose of this Feasibility Study (FS) is to develop, evaluate, and compare remedial action alternatives that will be used to mitigate hazards and threats to human health and the environment from soil and groundwater contamination at Operable Unit 2 (OU 2), at the Naval Air Station (NAS) Pensacola. This FS addresses remedial alternatives for soil and/or groundwater at the six sites which comprise OU 2: Sites 11, 12, 25, 26, 27, and 30.

This FS is being performed under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and the Superfund Amendments and Reauthorization Act of 1986, based on the findings reported in the *Remedial Investigation Report OU 2, Naval Air Station, Pensacola, Florida* (EnSafe/Allen and Hoshall [E&A/H], 1998).

The organization of this FS report has been adopted from the format suggested in Office of Solid Waste and Emergency Response (OSWER) Directive 9355.3-01, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (Interim Final, October 1988).

This FS is streamlined to provide an effective and efficient evaluation of remedial action alternatives and is organized in the following manner:

- Section 1, Introduction
- Section 2, Feasibility Study Process
- Section 3, Site 11 Soil Feasibility Evaluation
- Section 4, Site 12 Soil Feasibility Evaluation
- Section 5, Site 25 Soil Feasibility Evaluation
- Section 6, Site 27 Soil Feasibility Evaluation
- Section 7, Site 30 Soil Feasibility Evaluation

- Section 8, Sites 11, 12, and 26 Groundwater Feasibility Evaluation
- Section 9, Sites 25, 27, and 30 Groundwater Feasibility Evaluation

Section 1 presents site history and background information for OU 2 and summarizes the results of previous investigations, including the remedial investigation (RI) and baseline risk assessment (BRA).

Section 2 summarizes the general FS process, discussing major considerations for each task outlined below.

- Steps to define the remedial action objectives and areas requiring remedial analysis.
- Initial screening for remedial technologies.
- Development of remedial alternatives, including an implementability, effectiveness, and cost screening.
- Detailed analysis of alternatives.
- Comparative analysis of alternatives.

Because soil contamination and surface conditions at each OU 2 site is different, soil for each site is evaluated separately. Groundwater remediation feasibility, however, is evaluated for grouped sites (Sites 11, 12, and 26, and Sites 25, 27, and 30) due to their close proximity. Soil at Site 26 did not exceed a residential 1E-06 risk threshold, therefore the RI recommended this site for no further action. Site 26 will be discussed in the FS only in context of groundwater adjacent to Sites 11 and 12.

1.1 Site Descriptions and History

OU 2 (Sites 11, 12, 25, 26, 27, and 30) is in the northeast portion of NAS Pensacola as shown in Figure 1-1, Site Location Map, and Figure 1-2, Site Distribution Map. These sites were grouped as an operable unit because they are located near each other and within the same watershed. OU 2 extends from the western edge of the golf course east to the Yacht Basin.

1.1.1 Site 11 — North Chevalier Field Disposal Area

The North Chevalier Field Disposal Area, Site 11, is a former landfill where industrial and municipal wastes were disposed of and burned from the late 1930s to the mid-1940s. The area occupies approximately 20 acres next to an arm of Bayou Grande called the Yacht Basin (north of former Chevalier Field). Surface elevations on the site are approximately 5 feet above mean sea level (msl) and topography slopes gently eastward toward Bayou Grande. Two prefabricated buildings, Buildings 3627 and 3628, are near the center of the site. Building 3445, at the site's southeastern corner, is used to store outdated office equipment. A fenced area north and south of Building 3445 is used for outside storage of boats, trucks, and heavy equipment. Pat Bellinger Road runs north-south through the site's center.

1.1.2 Site 12 — Scrap Bins

Site 12 is currently referred to as the Defense Reutilization and Marketing Office (DRMO) Recyclable Materials Center, used to store scrap metal. The site is approximately 800 feet northwest of former Chevalier Field and immediately west and upgradient of Site 26. Most of the site area is enclosed by a chain-link fence and covered with a large concrete pad where heavy equipment is kept. Surface elevations average 15 to 18 feet above msl and the terrain is relatively

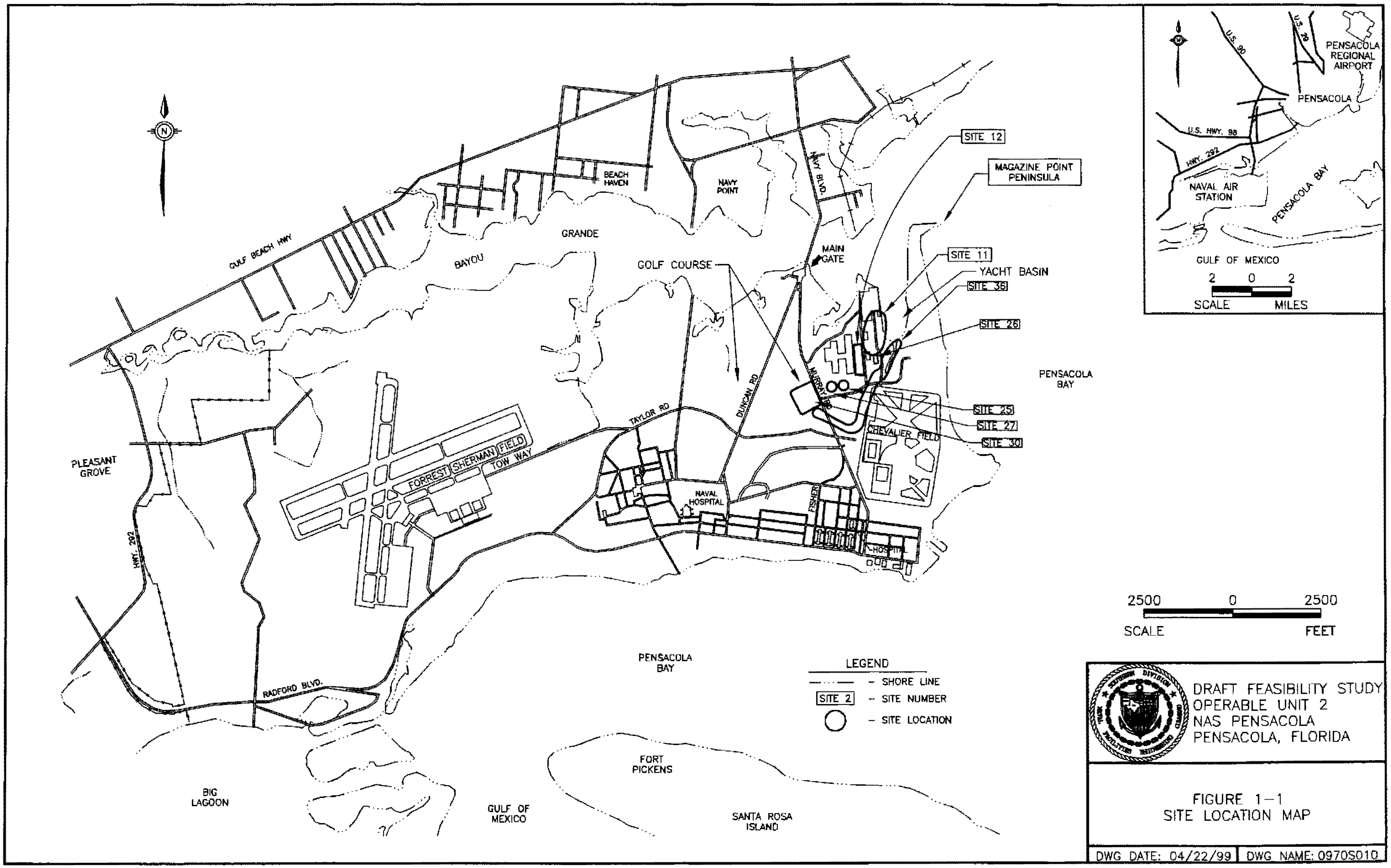

FIGURE 1-1
SITE LOCATION MAP

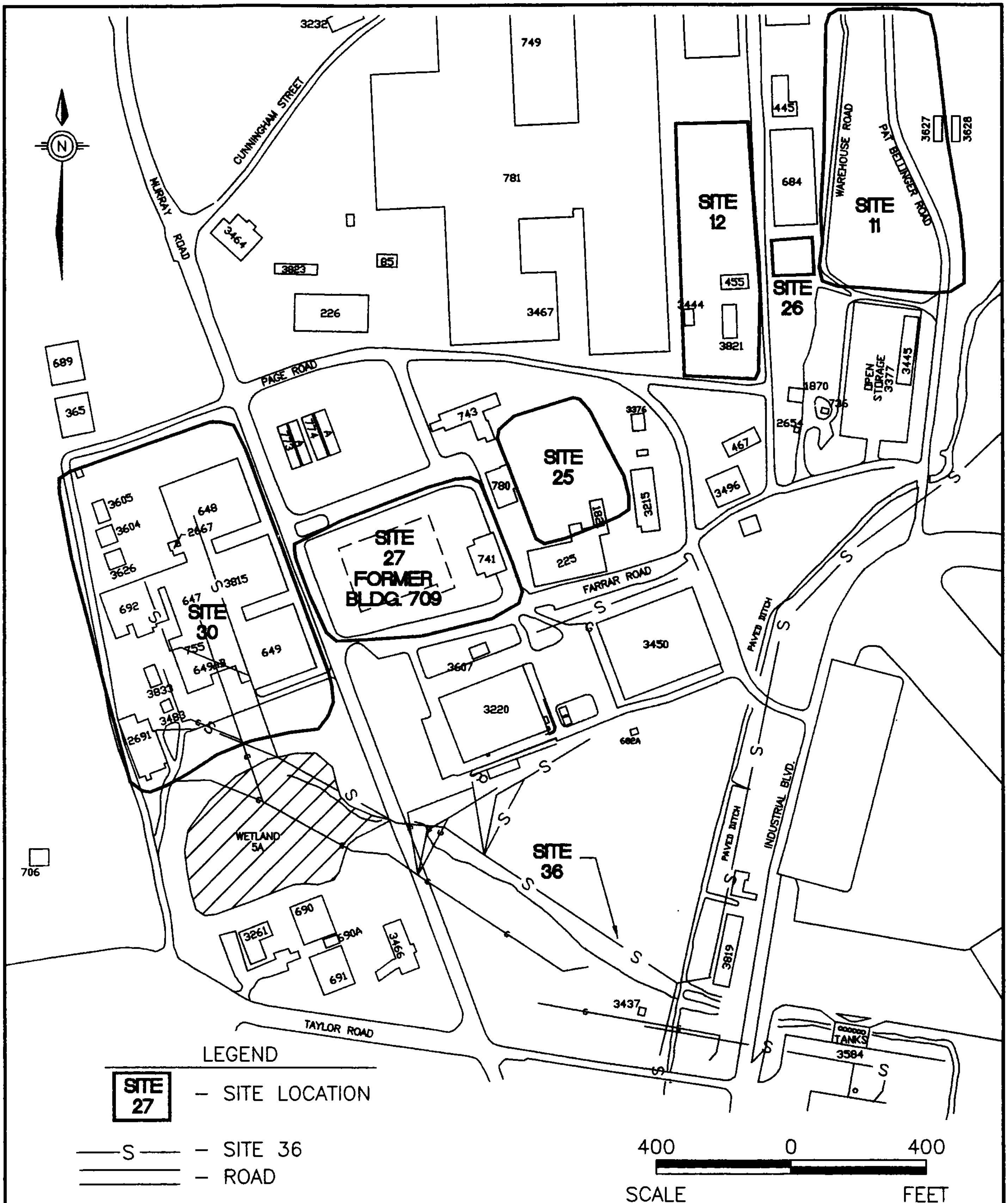

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FIGURE 1-2
SITE AREA MAP

DWG DATE: 04/22/99 | DWG NAME: 0970S009

flat. The limited exposed surface soil is sandy and well-drained. Buildings 455 and 3821 are in the southern portion of the site. Building 455 houses an office, break area, and storage warehouse, while Building 3821 is a storage warehouse.

1.1.3 Site 25 — Radium Spill Area

This approximately 50- by 50-foot concrete-paved area is in the eastern portion of NAS Pensacola, immediately east of Murray Road and north of Farrar Road. The site includes an area east of the radium decontamination building (Building 780), where a radium spill is reported to have occurred. A former helicopter scrap yard approximately 25 feet east of Building 780 is currently used as a parking area for Navy Exchange semitrailers. The fenced yard is unpaved and covered with interlocking perforated metal sheets. Building 780 currently houses the Joint Oil Analysis Laboratory, used for quality assurance analysis of oil from aircraft and vehicles. The site is flat with land surface elevations averaging approximately 22 to 25 feet above msl. Where exposed, site surface soil is sandy and well-drained.

1.1.4 Site 26 — Supply Department Outside Storage Area

The Supply Department Outside Storage Area, Site 26, is northwest of former Chevalier Field and immediately south of Building 684. The approximately 150- by 200-foot area houses an open metal shed near a former chemical storage building. Currently DRMO uses this area to store paints, fuels, and solvents. An 8-foot chain-link fence surrounding the storage area limits access. The concrete pavement inside the fence is bordered by sandy soil and mowed grass. Site 26 is bounded on the west by a paved road and on the east by a wooded area (Site 11). The site gently slopes eastward to a topographic break, where elevations abruptly drop to approximately 5 feet above msl.

1.1.5 Site 27 — Radium Dial Shop Sewer

The Radium Dial Shop Sewer extends through Building 709's remaining concrete foundation, which is currently a parking lot. The building foundation is 2 to 4 feet above the surrounding area. Beyond the building foundation, the sewer easement is unpaved. The site is approximately 150 feet west of Building 780 (Site 25) and bounded by Farrar and Murray roads on the south and west, respectively. An adjacent parking lot north of the building foundation is asphalt-paved, and a gravel and shell parking lot is next to the foundation's northeastern side. All area roads are paved with either concrete or asphalt. Originally, this site consisted of a small radium dial shop in former Building 709 with a connection to the sanitary sewer. However, recent investigations have associated additional areas of contamination with the site, expanding the area of investigation to approximately 6 acres.

1.1.6 Site 30 — Complex of Industrial Buildings and IWTP Sewer Line

This approximately 35-acre site houses a complex of industrial buildings — known as the Building 649 complex (interconnected Buildings 647, 648, 649, 692, 755, 3815, and several smaller separate, but associated, buildings). Housing the Dynamic Component Division of the former Naval Aviation Depot (NADEP), several aircraft component repair functions were carried out here. Operations in this complex began in the 1940s and continued until NADEP closed. Also included in the Site 30 investigation were the areas surrounding Buildings 3220 and 3450, former NADEP buildings where aircraft electronics were repaired. The Site 30 investigation also included a portion of the industrial wastewater treatment plant (IWTP) sewer line from the Building 649 complex to the wastewater treatment plant. The portions of the sewer investigated with Site 30 include those associated with Sites 25, 27, and 30, and downstream segments. These include the segment extending from the Building 649 complex, the feeder line from Building 3220, and the main line running to the IWTP.

The boundaries and location of Site 30 have changed in recent years to include Site 31, but exclude the nearby wetlands being investigated under Site 41. Site 31 was a former petroleum site turned over to the Installation Restoration Program (IRP) because of chlorinated solvents found during assessment. Site 41 assessed base wetland resources for contamination from IRP sites.

1.2 General Site Histories

1.2.1 Site 11

According to the Initial Assessment Study (IAS) conducted by the Naval Facilities Engineering Service Center (NFESC), this landfill was used to burn refuse through the mid-1940s. During this time, it received combustibles such as fuels, solvents, and waste oil from aircraft engine overhauls. During landfill operations from the early 1930s to the 1940s, approximately 24 cubic yards (CY) of material were disposed of daily from several NAS Pensacola locations. During this time, an unknown number of 55-gallon drums of unknown contents were observed at this site. Until the 1950s, oil slicks were noted during heavy rains in the Yacht Basin (NEESA, 1983).

1.2.2 Site 12

From the early 1930s to the 1940s, garbage was stored at Site 12 in an area known as "Pig Sty Hill" near Building 455. Approximately 16 CY (two truckloads) per day of wet garbage were stored here before being hauled off for livestock feed. The site has since been used as a scrap metal storage area (NEESA, 1983).

1.2.3 Site 25

Building 780 was constructed in 1951 to house the oxygen and carbon dioxide shops. In approximately 1975, a radium decontamination operation was added. Radium wastes from this operation were stored in a drum onsite before being disposed of. In 1978 a spill occurred in the storage area between Building 780 and the scrap yard. Approximately 25 gallons of low-level radium paint waste spilled from a ruptured, corroded drum onto the underlying concrete floor (NEESA, 1983). The waste was reportedly cleaned up, placed in a secure container, and sent to a proper disposal site. The exact location of the spill, the details of the cleanup operation, and whether the waste reached unpaved soil have not been determined from the currently available records (Ecology and Environment [E&E], 1992a).

1.2.4 Site 26

From 1956 until 1964, the supply department used Site 26 to store incoming paint strippers and acids. Containers of these materials placed outside on steel matting sometimes leaked, discharging the materials onto the ground (Geraghty and Miller [G&M], 1984).

1.2.5 Site 27

Building 709, constructed in 1941, has been used for several operations such as carburetor repair, propeller repair, painting and maintenance, and various instrument shops (including a radium paint room), and a plating shop (E&E, 1992b). In 1949, a small shop in Building 709 was used to rework luminous instrument dials. It was here that worn and damaged instruments were returned to be stripped and repainted. From 1941 to 1965, the stripping procedure required soaking the instruments in benzene, scraping them in a benzene or water bath, or dry scraping and painting them under a ventilation hood. After 1965, the procedure switched to scanning the instruments for radium, then stripping them with paint stripper and a lye-nitric acid solution. Contaminated instrument cases were soaked in another acid solution called "Turco" then scrubbed with a wire brush (NEESA, 1983).

Building 709 also housed a large plating operation from 1941 to approximately 1970. The operation involved the use of 50 solution tanks ranging from 50 to 3,865 gallons in capacity (E&E, 1992b).

A routine disposal operation in Building 709 involved washing spent cleaning solutions and luminous paint down the drains into the sanitary sewer. The wastes disposed of from this location were cleaning solutions containing benzene, white pigments, phosphors, radium, and small amounts of acidic or caustic solutions. Plating wastes from Building 709 and shops in Buildings 604 and 649/755 were periodically dumped through drains into the sanitary sewer. Most building drains connected to a single line draining to the sanitary sewer line. From 1941 to 1948, all wastes from Building 709 were discharged directly into Pensacola Bay. From 1941 to 1962, concentrated cyanide wastes from Building 709 were periodically dumped into the sanitary sewer. After 1962, the cyanide was drummed and disposed of 15 miles offshore in the Gulf of Mexico, although small quantities of cyanide continued to be discharged into the sewer. Plating operations ceased in Building 709 in 1970 or 1973 (NEESA, 1983). Today, Building 709 has been removed and the old building floor is used as a parking lot.

1.2.6 Site 30

Aircraft and parts were painted in booths in the Building 649 complex beginning in 1940. The paints used at NAS Pensacola were cellulose nitrate lacquer, zinc chromate, nitrate dope, acetate dope, "day glow," epoxy, and enamel. Thinners used were lacquer thinner, toluene, and M-T-6096 (NEESA, 1983).

A tin-cadmium plating shop operated in the Building 649 complex from the mid-1940s to the early 1960s. At this time, it was replaced by a magnesium treatment line which operated there until the early 1970s. Near Building 649, 15 tanks ranging in capacity from 200 to 500 gallons contained solutions of tin, cadmium, and cyanide. Additionally, a 250-gallon tank stored trichloroethylene (NEESA, 1983), and a 500-gallon UST on Building 649's north end stored waste oil (F. Graham, 1993, personal communication). The contents were drained periodically into a "ditch" east of the buildings. Based on current topography and historical data, this "ditch" was either Wetland 5A or a topographical low draining into it. When the tin-cadmium operation was replaced by a magnesium treatment line in the early 1970s, the 15 tanks near Building 649 were then used to store acids, caustics, degreasers, chromate solutions, and potassium permanganate (NEESA, 1983).

In the summer of 1994 as part of an interim removal action, the Public Works Center (PWC) removed an aircraft engine shipping container from a wetland immediately southeast of Building 649. It had been used as an oil-water separator. Since then, E/A&H sampled this wetland under the Site 41 investigation as Wetland 5A. A second plating shop in Building 755 was used from the early 1960s until the early 1970s. Fifty tanks ranging in capacity from 50 to 200 gallons contained metal plating solutions, including nickel, chromium, silver, lead, and tin (NEESA, 1983).

Concentrated cyanide wastes generated in Buildings 649 and 755 were disposed of in the same manner as Building 709's cyanide waste. Disposal involved discharging the wastes down the sewer from 1941 to 1962, and discarding drummed waste in the Gulf after 1962. Overflow discharged into the sewer (NEESA, 1983).

An empty fiberglass UST mounted in concrete is still near Building 692's southeast corner. Installed in 1986, this tank stored JP-1/JP-5 (jet fuel) calibration fluid for use in Building 692. The fiberglass tank replaced an older steel tank also used to store calibration fluid. The older tank had at least one undocumented spill. A UST along the west side of Building 692 supplied Building 755 with methyl ethyl ketone (MEK) via underground pipes. Several other USTs were along the entire north side of Building 692; their exact contents are unknown. Some of the storage tanks may have contained chromium wastes (F. Graham, 1993, personal communication).

In 1973, minor painting operations began in Building 3450 (NEESA, 1983). Several 1,000-gallon USTs along the south wall of Building 3450 were reportedly used to store gasoline (ABB, 1993).

Several tanks near Building 3220 included a diesel UST near the southeast corner, a waste oil UST on the south wall, and a series of USTs approximately 50 feet south of the waste oil tank (ABB, 1993b).

The wastewater treatment plant, originally built in 1948, was replaced in 1971 with a modern plant that could accept industrial wastes. Most facilities discharging to the sewer did so without any pretreatment or waste segregation. The waste stream has included paint strippers, heavy metals, pesticides, radioactive wastes, fuels, cyanide waste, and waste oil (NEESA, 1983). Beginning in 1973, the Naval Air Rework Facility operations discharged to the sewer instead of to Pensacola Bay. The IWTP sewer consisted of vitreous clay and cast-iron piping installed both before and after 1971 (E/A&H, 1997).

Previous Investigations

Multiple investigations were conducted in this area before completion of the RI. For additional information regarding previous investigations and removal actions, please reference the OU 2 RI report.

1.3 Environmental Setting

1.3.1 Physiography

NAS Pensacola is in the Gulf Coast lowlands on a peninsula bounded by Pensacola Bay to the south and east and Bayou Grande to the north. The main topographic feature is a bluff paralleling the southern and eastern shorelines of the peninsula. Landward of the bluff is a gently rolling upland with elevations up to 40 feet above msl (U.S. Geological Survey [USGS], 1970a and

1970b). In the eastern part of the base, a low and nearly level marine terrace lies east of the bluff with elevations of approximately 5 feet or less above msl, constituting the former Chevalier Field and Magazine Point areas.

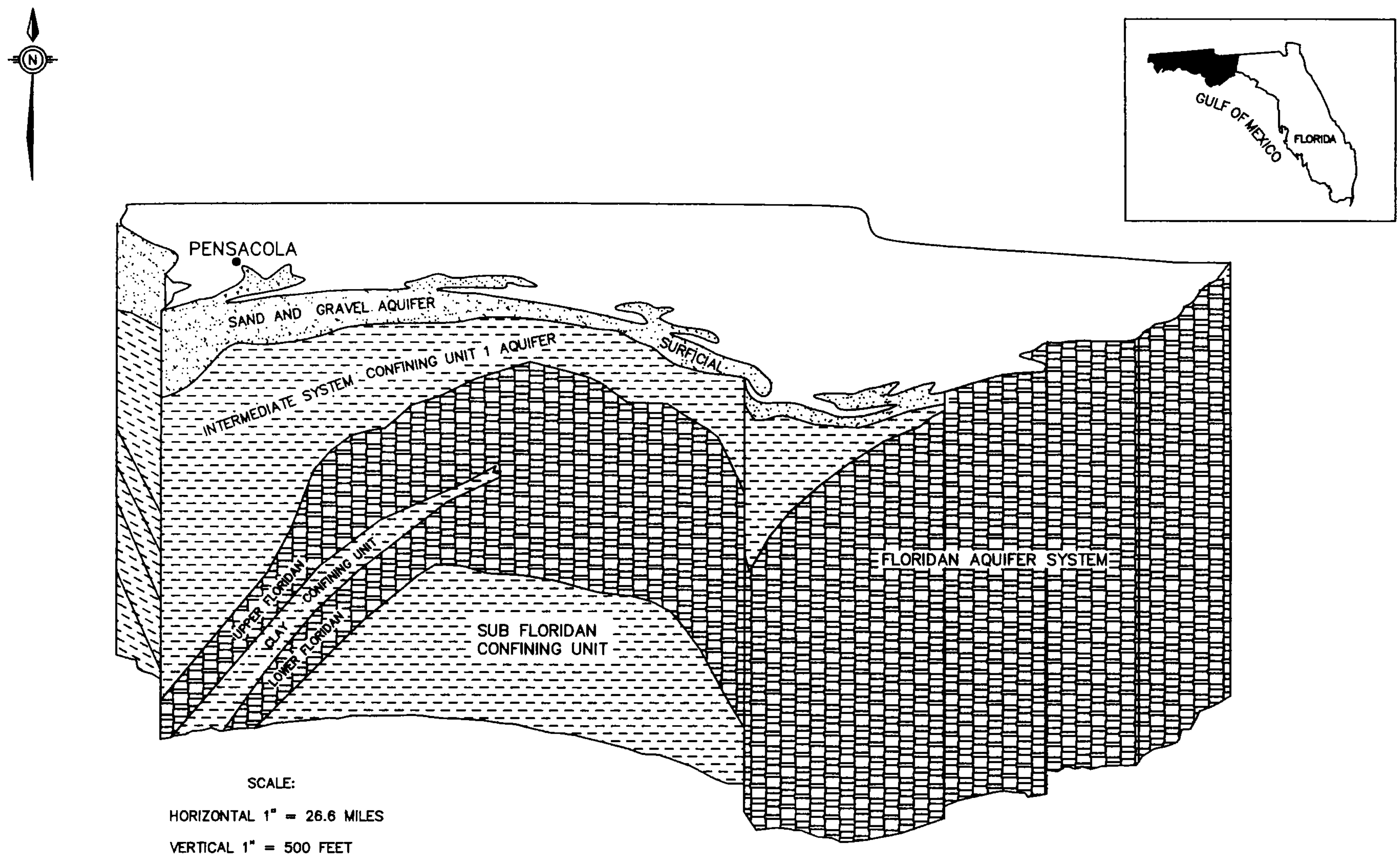
Sandy soils typify the NAS Pensacola area. Consequently, most rainfall infiltrates directly into the subsurface, resulting in few natural streams. Streams on base generally are man-made and channelized. Numerous natural wetlands occur in low-lying areas.

1.3.2 Stratigraphy and Hydrogeology

Stratigraphy beneath the Florida Panhandle generally consists of Quaternary marine terrace and fluvial deposits, underlain by a thick sequence of interlayered fine-grained clastic deposits and carbonate strata of Tertiary age (Southeastern Geological Society [SEGS], 1986). Three main regional hydrogeologic units have been described within this stratigraphic column (in descending order): the Surficial/Sand-and-Gravel Aquifer, the Intermediate System, and the Floridan Aquifer System. Figure 1-3 provides a generalized cross-section of these hydrogeologic units in northwest Florida.

Surficial/Sand-and-Gravel Aquifer

The Surficial Aquifer, composed primarily of unconsolidated siliciclastic sediments, is approximately 300 feet thick at NAS Pensacola. These sediments belong to undifferentiated Pleistocene-Holocene terrace deposits, the Pliocene Citronelle formation, and underlying Miocene coarse clastics (Wilkins et al., 1985). West of the Choctawhatchee River in northwest Florida, the Surficial Aquifer is referred to as the Sand-and-Gravel Aquifer, and is a major source of drinking water (SEGS, 1986). The Florida Department of Environmental Protection (FDEP) classification of the Surficial Aquifer is G-1, with a U.S. Environmental Protection Agency (USEPA) classification of IIA. Because the Sand-and-Gravel Aquifer is the uppermost unit



SCALE:

HORIZONTAL 1" = 26.6 MILES

VERTICAL 1" = 500 FEET

VERTICAL EXAGGERATION = 281

SOURCE: E&E 1992c.

DRAFT FEASIBILITY STUDY
OPERABLE UNIT 2
NAS PENSACOLA
PENSACOLA, FLORIDA

FIGURE 1-3
GENERALIZED GEOLOGIC CROSS-SECTION OF HYDROGEOLOGIC UNITS IN NORTHWEST FLORIDA

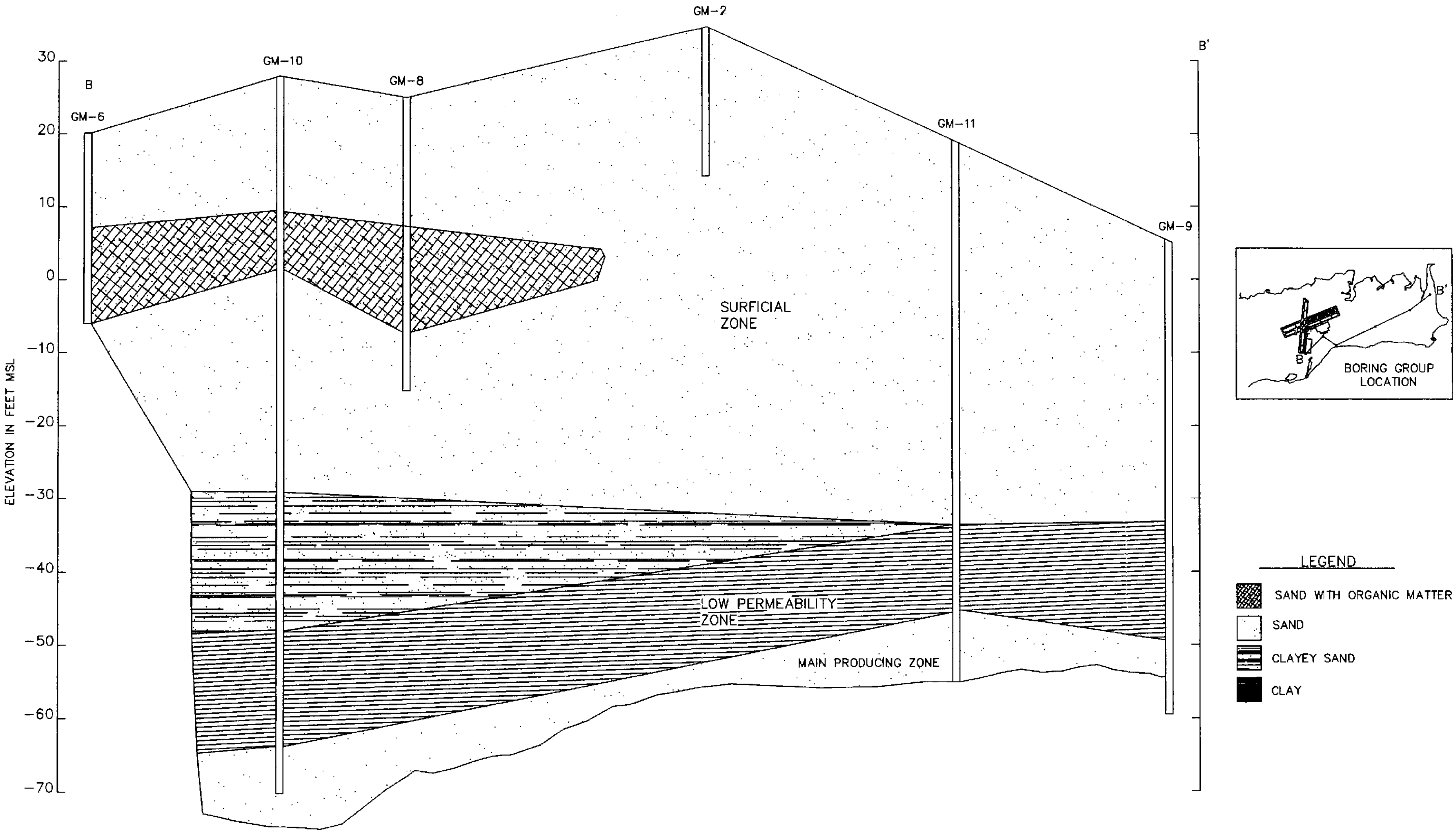
DWG DATE: 04/22/99 | DWG NAME: 0970S006

contiguous with land surface and receives recharge through direct infiltration, it is susceptible to contamination from surface activities. Near NAS Pensacola, the unit has been subdivided into three distinct zones based on hydrogeologic differences (in descending order): the surficial zone, the low-permeability zone, and the main producing zone (Wilkins et al., 1985). This investigation focuses on the upper (shallow depth) and basal (intermediate depth) portions of the surficial zone. A generalized cross-section of the Sand-and-Gravel Aquifer produced by G&M (1984), as shown in Figure 1-4, illustrates the stratigraphic relationship of these zones.

Surficial Zone

The surficial zone is contiguous with land surface and contains groundwater under water table or perched conditions. At NAS Pensacola, the surficial zone is approximately 40 to 60 feet thick and is generally composed of a poorly graded quartz sand (G&M, 1984 and 1986). Beneath the western side of the base, a substantial stratum of sand with abundant organic matter occurs within the zone and pinches out to the east. Depth to groundwater ranges from 0 to 20 feet depending on ground surface elevation.

Aquifer tests have yielded high hydraulic conductivities, on the order of 10 to 100 feet/day (E&E, 1990). The lower contact with the low-permeability zone is transitional, resulting in a fining downward sequence in the lower portion of the surficial zone proper. Generally, the low-permeability zone is thicker to the west, and thins to the east. This increased clay content in the transition from the surficial to the low-permeability zone is responsible for lower hydraulic conductivities measured in the base of the surficial zone. Shallow groundwater flow in the surficial zone is generally influenced by topography, usually flowing toward and discharging to the nearest surface water body.



SOURCE: GERAGHTY & MILLER, 1986

DRAFT FEASIBILITY STUDY
OPERABLE UNIT 2
NAS PENSACOLA
PENSACOLA, FLORIDA

FIGURE 1-4
GEOLOGICAL CROSS-SECTION OF THE SURFICIAL AQUIFER AT NAS PENSACOLA

DWG DATE: 04/22/99 | DWG NAME: 0970S007

Low-Permeability Zone

The low-permeability zone, which underlies the surficial zone, is characterized by clay and silt-sized sediments. At NAS Pensacola, this zone comprises gray to blue-gray sandy and silty marine clay with some shell fragments and clayey sands, with total thickness ranging from 8 to 40 feet (G&M, 1984 and 1986). The upper contact is transitional with the overlying surficial zone; however, the top of the low-permeability zone is marked by the first occurrence of a stiff blue-gray clay. Studies at NAS Pensacola indicate the low-permeability zone is continuous beneath the air station.

Hydraulic conductivities of the low-permeability zone are much lower than the overlying surficial zone, ranging between the orders of 0.0001 foot/day for clays and 1 foot/day for clayey sands (G&M, 1986). Hence, the low-permeability zone acts as a confining or semiconfining layer to inhibit groundwater flow between the overlying surficial and underlying main producing zones.

Main Producing Zone

The main producing zone underlies the low-permeability zone and constitutes the bottom portion of the Sand-and-Gravel Aquifer. Regionally, depth to the top of the zone ranges from 60 to 120 feet. The zone is composed of sand and gravel with thin beds of silt and clay, estimated to be approximately 300 feet thick at NAS Pensacola. Of the three zones in the Sand-and-Gravel Aquifer, this one is generally the most permeable and is the principal source of water supply for the Pensacola area (Wilkins et al., 1985). Groundwater in this zone is confined ,being recharged in northern Escambia County where it is present at the surface. In the vicinity of NAS Pensacola, the main producing zone is supplemented by leakage. Regional groundwater flows generally east toward Pensacola Bay and south toward the Gulf of Mexico. Three supply wells at NAS Pensacola produce water from this zone. However, the water has a high iron content and the wells are used only to supplement the base water supply, used for irrigating the base golf course and for fire protection (G&M, 1984 and 1986). For potable water, NAS Pensacola depends on an offsite source provided from main producing zone wells at Corry Field, approximately three miles to the north.

Intermediate System

The Intermediate System, a regionally and vertically extensive, laterally persistent hydrologic unit, underlies the Surficial/Sand-and-Gravel Aquifer. The system comprises fine-grained clastic units of Miocene age (Pensacola Clay, Alum Bluff Group) that lie beneath coarse clastics of the overlying Sand-and-Gravel Aquifer. In the NAS Pensacola vicinity, depth to the top of the unit is approximately 300 feet, with a thickness of approximately 1,100 feet (Wilkins et al.,1985; SEGS, 1986). The system is regionally characterized by poor to non-water-bearing conditions. Permeabilities are much lower than those of the overlying Sand-and-Gravel Aquifer and the underlying Floridan Aquifer System, and consequently the system functions as a confining unit for the underlying Floridan Aquifer System (SEGS, 1986).

Floridan Aquifer System

The Floridan Aquifer System underlies the Intermediate System at an approximate depth of 1,400 feet in the NAS Pensacola area. The unit is predominantly limestone, but is separated into upper and lower units by a significant clay layer called the Bucatunna Clay. Groundwater within the Floridan System is highly mineralized in the NAS Pensacola area and is not used for water supply (Wagner et al., 1984). However, groundwater from the Upper Floridan Aquifer is used for water supply approximately 25 miles east of NAS Pensacola.

1.3.3 Background Water Quality

As discussed in previous documents (*Site 1 Remedial Investigation Report*, E/A&H January 5, 1996), background wells were installed next to water supply wells to assess background water quality at NAS Pensacola. To assess overall backgound water quality, inorganic concenetrations from these wells were compared to Floriday Primary and Secondary Drinking Water Standards (FPDWS, FSDWS) as well as criteria identified in proposed rule 62-777. This comparison procedure is outlined in Floridas UST (62-770) and Brownsfields (62-785) rules, which were identified as relevant and appropriate regulations under CERCLA, as shown in Appendix A. The comparison of backgorund data and inorganic standards is shown in Appendix B, and is summarized in Table 1-1 below.

Table 1-1
NAS Pensacola Background Well Data versus Florida Standards

Element	Mean Background Concentration (μg/L)	Reference Concentration (μg/L)	Florida Standard (μg/L)	
Aluminum	1,941.38	3,882.76	200	Secondary
Iron	853.9	1,707.8	300	Secondary

Note:
μg/L = micrograms per liter

Clearly, mean aluminum, iron concentrations are significantly above state standards.

It is important to note that these data were collected from background locations completed in the upland portion of NAS Pensacola and indicate water quality in areas not impacted by former industrial operations. Additional exceedances are consistently noted at sites located on the marine terrace downgradient of the uplands. Manganese in particular is characteristic of marine terrace groundwater; manganese exceedances were noted consistently at OU 2, further characterizing the aquifer as poor quality using relevant and appropriate rules.

Given Florida Rules 62-770 (Petroleum Contamination Site Cleanup Criteria), 62-781 (Dry Cleaning Solvent Cleanup Program), and 62-785 (Brownfields Cleanup Criteria), groundwater of low yield/poor quality criteria cleanup target levels are relevant and appropriate for OU 2 groundwater since background concentrations exceed Florida's secondary drinking water standards in accordance with these rules, the site would require institutional controls for all remedial alternatives to ensure that the contaminated groundwater would not be consumed.

Florida rules, particularly the UST regulation, have consistently applied to CERCLA sites at NAS Pensacola. The poor quality groundwater designation has been applied to UST sites 18 and 26, and therefore is a classification consistent with other remedial activities on base.

1.3.4 Ecological Setting

Regional Ecological Setting

According to Wolfe et al. (1988), the Florida Panhandle has a wide variety of surface waters and physiographic regions, producing an ecological diversity found in few other areas of the United States. Panhandle watersheds support a diverse array of habitats and vegetative communities. Bottomland hardwoods predominate in river floodplains, and pines mixed with a variety of other shrubs prevail in upland areas. Wetlands are prevalent along the coastal fringe and river floodplains. Barrier islands support dune vegetation communities and salt marshes. Intertidal and subtidal bays support seagrass meadows and oyster reefs.

Seven major rivers in the region discharge into seven bar-built estuaries at the mouths of the rivers. The Florida Panhandle is a crossroads where animals and plants from the Gulf Coastal Plain reach their eastward distributional limits, and where many northern species reach their southern limits. Many peninsular Florida species are also distributed there. Due to the wet temperate climate, the panhandle area may support the highest diversity of species of any other similar-size territory in the U.S.

The region's high annual rainfall and low, gently sloping terrain create numerous wetlands. Bogs, swamps, marshes, wet prairies, and wet flatwoods provide a diversity of wetland types supporting a wide variety of flora and fauna. Terrestrial vegetation includes open pine woods and hardwood forests; most are second-growth forests of pines and encroaching hardwoods.

The Florida Panhandle's estuaries and nearshore marine habitats are some of the greatest natural and economic assets of the region. Important commercial organisms (such as oysters and fish) abound and contribute to the region's economy. Coastal saltmarsh habitats provide critical nursery, feeding, and refuge for these important commercial species. Seagrass beds within estuaries also are vital to the seafood industry.

Ecological Setting at NAS Pensacola

NAS Pensacola, which occupies approximately 5,800 acres, is bounded by Bayou Grande to the north and Pensacola Bay to the east and south. To the west, the installation changes to less developed swampy lowlands. NAS Pensacola's eastern portion is mostly developed, with military and industrial facilities and historical/cultural sites. Most of the installation's activities are on the eastern side of the base. The less developed west side has approximately 3,500 acres of natural or seminatural beaches, forests, and wetlands.

NAS Pensacola is the setting for numerous aquatic and terrestrial habitats, from coastal strand and estuarine environments along the bay and bayou to inland pine flatwood communities. Wetland environments include a broad spectrum of both estuarine and palustrine wetlands, as well as various disturbed habitats, many in states of recovery as they undergo reforestation or return to their natural condition.

Vegetation Communities

NAS Pensacola natural vegetation communities fall into several broad categories: (1) coastal dune scrub communities, (2) pine flatwood communities, (3) hardwood/pine communities, (4) sand pine scrub communities, (5) bay swamps, (6) freshwater marshes, and (7) estuarine coastal marshes. Coastal dune scrub communities are associated with shorelines subject to high-energy waves. The vegetation consists of salt-tolerant plants able to establish themselves in shifting sands. Pine flatwood communities in coastal lowlands are characterized by trees that can tolerate various soil moisture conditions. Tree species in flatwood communities are short, with a wide variety of small shrubs and herbaceous plants in the understory. Hardwood/pine communities are a highly diverse mixture of hardwood trees and pines. Sand pine scrub communities on well-drained sandy soil contain sand pines, oaks, and various shrubs. Bay swamps are wetlands with titi and cypress swamps known to contain permanent standing water and large accumulations of organic peat. Freshwater marshes occur as grass/ sedge/rush/herb communities in areas with high soil saturation or standing water. Estuarine coastal marshes, including salt marshes, occur along low-energy shorelines and in tidal bayous (U.S. Fish and Wildlife Service [USFWS], 1987).

Wildlife

NAS Pensacola provides potential habitats for a wide variety of animal life such as deer, squirrel, opossum, raccoon, fox, beaver, and bobcat. The station's beaches serve as resting, feeding, and nesting areas for various shorebirds. Ospreys have been observed nesting along undeveloped shoreline areas of the Big Lagoon, southeast of the Forrest Sherman Airfield. Numerous small mammals, amphibians, and reptiles also inhabit the base. The coastal marsh, submerged grass bed, and shallow water habitats at NAS Pensacola help support fishery communities within the Pensacola Bay estuarine complex. Approximately 180 species of bony fishes form the basis of the Pensacola Bay fish community (USFWS, 1987).

Threatened and Endangered Species

Appendix A of the *Comprehensive Natural Resources Management Plan for NAS Pensacola and Outlying Field Bronson* (USFWS, 1987) lists the rare, threatened, and endangered species that may be found within NAS Pensacola boundaries. EnSafe investigations have identified osprey, great blue heron (as well as other shorebirds), alligator snapping turtle, Godfrey's golden aster, Carolina lilaeopsis, white-top pitcher plant, and narrow-leaved sundew. All are considered rare or endangered for Escambia County, Florida (Florida Natural Areas Inventory, 1995).

Area Climate

The Pensacola area has a mild, subtropical climate with average annual temperature ranging from 55°F in the winter to 81°F in the summer. Daily temperatures can be more extreme, from below than 7°F in the winter to above 102°F in the summer. Thunderstorms, which occur on approximately half the summer days, can cause a precipitous temperature drop of 10° to 20°F in a matter of minutes (E&E, 1992a).

November is the driest month of the year with an average rainfall of 3.2 inches, based on climatological data from 1962 to 1991. Rainfall averages approximately 60 inches a year, with the highest amounts in July and August when thunderstorms occur almost daily. Thunderstorms commonly produce 3 to 4 inches of rain per hour. Rainfall is lowest during spring and fall (4 inches average per month), when rains are generally less intense, last longer, and produce less surface runoff. Higher rates of infiltration and net recharge, however, characterize spring and fall rainfall events (E&E, 1992c).

Winds, which prevail from the north during the winter and the south during the summer, are generally moderate in velocity except during thunderstorms. A difference in the ocean-land temperature produces the sea-breeze effect, a daily clockwise rotation in the surface wind direction near the coast. Hurricanes and tornadoes can substantially damage the nearshore environment. Since 1980, nine hurricanes have passed within 50 miles of Pensacola, including Hurricanes Erin and Opal in August and October 1995, respectively, and the most recent, Hurricane Georges in 1998.

1.4 Geological and Hydrogeological Results

This section summarizes the results of drilling, monitoring well installation, field observations, mapping studies, and physical measurements of soil, sediment, groundwater, and surface water at OU 2.

1.4.1 Site Geology

Site-specific geological and stratigraphic information developed while advancing soil borings was consistent with previous studies. All soil borings were confined to the surficial and low-permeability zones of the Sand-and-Gravel Aquifer. Twenty-one intermediate well/borings penetrated the full thickness of the surficial zone and 129 borings were confined to the upper surficial zone for shallow monitoring wells. Details of the generalized geologic section are listed in Table 1-2.

Table 1-2
Generalized Geologic Section

Site Number	Sample Interval (in feet)	Lithology
Sites 11, 12, 25, 26, 27, and 30	0-1	Brown-to-tan, fine-grained to silty quartz sand mixed with sandy loam, loamy soil, clayey silt, organics, brick, rock fragments, gravel, oyster shell, and some debris.
	1-3	Tan-to-brown-to-black, red clayey, fine-grained quartz sand mixed with gravel, a few rock, and clay fragments.
	3-5	White-to-tan-to-dark brown, fine- to medium-grained quartz sand.

Table 1-2
Generalized Geologic Section

Site Number	Sample Interval (in feet)	Lithology
	5-45	Tan-to-white, silty, fine-grained quartz sand with intermittent lenses of dark sandy clay and clayey sand near the bottom of the interval.
	45-60	Sandy and medium stiff clay with occasional shell fragments. Color is light to medium gray and occasionally green in the low-permeability zone.

Surficial Zone

The surficial zone at OU 2 varies from 40 to 65 feet thick. The underlying clay (the low-permeability zone) is relatively flat, making the surficial zone thickness dependent on the topographic elevation of the overlying strata. A layer of silty sand with occasional clay lenses, varying in thickness from 0 to 5 feet, overlies the clay. It is discontinuous laterally, frequently pinching out between adjacent borings, and appears to be a transitional zone between the clay and overlying surficial zone sands.

Low-Permeability Zone

The low permeability zone of the Sand-and-Gravel Aquifer lies beneath the surficial zone forming a semiconfining unit in this area. The low-permeability zone consists of a plastic green to gray marine clay that is occasionally shelly at the top. The clay was encountered at the base of the surficial zone sands in all intermediate borings for this study, suggesting that it is continuous beneath the study area. The low permeability of this zone is described in the next section. The unit's thickness was not explored by EnSAfe, but according to G&M (1986) the thickness of this unit is reported at 30 feet in well GM-54, which is on Site 27 at the northeast corner of former Building 709.

1.4.2 Physical Property Analysis

Physical property analyses are summarized below for use in this FS; detailed data are presented in the RI.

Grain-Size Analysis

Typically, the surficial zone is made up of more than 90% sand-size particles with minor amounts of silt and clay-size particles. Samples collected from the transition zone contain 50% to 90% sand, 0% to 13% silt, and 10% to 34% clay-size particles. Samples from the low-permeability zone were made up of 5% to 37% sand, 11% to 35% silt, and 51% to 72% clay-size particles. Some samples from all three zones contain small quantities of coarse sand particles.

Permeability

Surficial zone sand has a median permeability of 1.8×10^{-2} centimeters per second (cm/sec). This sand is 92% to 98% sand with minor silt- and clay-size particles. More silty layers are discontinuous throughout the clay. Their permeability may be reduced by three orders of magnitude. Grain sizes in the transition zone vary from a slightly clayey sand to a slightly sandy clay, resulting in a highly variable permeability (between 5.6×10^{-3} and 3.3×10^{-5} cm/sec). Clay has a median permeability of 1.23×10^{-8} cm/sec, and typically varying by three orders of magnitude (1.217×10^{-6} cm/sec to 8.227×10^{-9} cm/sec). These permeability values provide a rough order of magnitude estimate in noncohesive deposits.

According to Fetter (1988), sediments with permeabilities of 10^{-5} cm/sec or less can be considered confining units. The lowest permeability in the clay layer suggests that the potential for groundwater movement through the clay is very low under ambient conditions.

Specific Gravity

The mean specific gravity of the clay, 2.55, is lower than that of the sand and the transition zone, 2.65. This change in specific gravity indicates that the mineralogy of the clay is different from that of the quartz sand. Field observations using hydrochloric acid effervescence further indicates that the clay contains calcareous materials.

1.4.3 Hydrogeological Results

This section evaluates factors affecting groundwater flow. Vertical and horizontal flow characteristics will be discussed along with the potential tidal influences.

Horizontal Groundwater Flow Velocity

Groundwater elevation varies from 13 feet in the western portion of OU 2 (Site 27) to less than a foot along the Yacht Basin. This highest-to-lowest groundwater elevation drop occurs across an approximate 2,500-foot horizontal distance. Groundwater elevations indicate a general west-to-east flow, verified by earlier studies which found that horizontal movement of groundwater in the surficial zone generally mimics topography (G&M, 1984). Locally, groundwater flows toward Wetland 5A (south of Site 30) and east-southeast toward the Wetland 5B stream and Wetland 6, which discharges to Bayou Grande. Figure 1-5 displays the shallow zone's potentiometric surface for Sites 11, 12, 25, 26, 27, and 30. The shallow zone is emphasized because of its higher permeability, closeness to suspected sources, and greatest potential for migration.

As shown in Table 1-3, the horizontal hydraulic gradient varies from 0.001 to 0.006 across OU 2, with the gradient being steepest near a wave-cut terrace. Three well pairs (30GS166/30GS123, 12GS05/11GS07, and 12GS15/11GS13) exhibit the hydraulic gradient across OU 2's prominent wave cut terrace. This topographic feature separates the highest terrace elevations from coastal flats. The fourth pair (30GS43/25GS09) describes the hydraulic gradient trending in an easterly direction toward the Yacht Basin, while the fifth pair (30GS43/30GS06) exhibits the gradient in a southerly direction toward Wetland 5A. These topographic features affect the hydraulic gradient and therein contaminant transport.

Table 1-3
Horizontal Hydraulic Gradients
Sites 11, 12, 25, 26, 27, and 30

Well Pair	Distance Between Wells (feet)	Difference Between Water Levels (feet)	Hydraulic Gradient	Groundwater Horizontal Velocity (feet/day)
12GS05 & 11GS07 (North terrace A-A')	830	1.1	0.001	0.89
12GS15 &11GS13 (East terrace B-B')	630	2.71	0.004	2.9
30GS166 & 30GS123 (South terrace C-C')	800	2.11	0.003	2.0
30GS43 & 25GS09 (East across OU 2: D-D')	1150	7.15	0.006	4.2
30GS43 & 30GS06 (South across OU 2: D-E')	500	1.9	0.004	2.6

Notes:
Specific capacity data were used to calculate hydraulic conductivity for the shallow and intermediate portions of the surficial aquifer during the field investigation. The geometric mean hydraulic conductivity was calculated at 167.7 feet/day (ft/day) for shallow wells. Using this value, the average pore groundwater velocity for the upper level of the surficial zone beneath the site was calculated using the following formula;

$$V = Ki/n_e$$

Where:

V = horizontal groundwater velocity
K = hydraulic conductivity
i = horizontal hydraulic gradient
n_e = effective porosity

For reference, hydraulic conductivities were taken from Table 6-6 in the OU 2 RI. An effective porosity of 0.25 is estimated for unconsolidated sand from Heath (1989). Data obtained from Shelby tube samples show shallow well porosity was 0.369 and intermediate well porosity, 0.403. Shelby tube porosity measures are not "effective" porosity by definition.

Vertical Hydraulic Gradient

Vertical groundwater gradients indicate the direction of vertical flow. Table 1-4 provides the vertical flow around Site 11 representing a coastal flat, and Table 1-5 compares groundwater levels in Sites 25 and 27 representing an upland terrace. These shallow and intermediate well pairs offer a direct measurement of vertical flow at that location. The vertical gradient is calculated by dividing the difference in hydraulic head by the difference in completion depths. A positive gradient indicates potential downward flow, while a negative gradient indicates a potential upward flow. Measurements for gradient determinations were made at high and low tides to define potential gradient reversals. Of the wells measured on the upland terrace, most had groundwater levels lower in the intermediate well than in the corresponding shallow well. This implies that groundwater flows from shallow to intermediate depths, which is indicative of a recharge area. In the coastal flats, most wells had a slight downward flow except for two well pairs, 11GS03/11GS04 and 11GS013/11GS014, which had a slight upward flow.

From Table 1-4, it can be seen that tides influence the vertical gradient in groundwater only in the coastal flats. No tidal influence was measurable in the wells of the upland terrace (Site 12, 25, 26, 27, and 30). The vertical gradient changed in only two well pairs with no reversal occurring. Since all the values for tidal change are less than zero, the effect is an overall increase in downward flow potential (i.e., increased gradient). All the shallow wells, indicated by a "GS" in the well number, had less than 0.03-foot change. The greatest water level changes due to tides were in the intermediate wells completed at the low-permeability zone. In summary, there are generally positive gradients across OU 2 with no tidal reversals.

Table 1-4
Coastal Flats Measurements

Well ID	Depth (ft)	TOC EL (ft msl)	April 1, 1997 High Tide (ft msl)	Time	GW Elevation (ft msl)	Shallow - Inter. (difference)	High Tide Gradient (ft/ft)	Low Tide	Time	GW Elevation (ft msl)	Shallow - Inter. (difference)	Low Tide Gradient (ft/ft)	Total Change
30GS113	12	9.20	7.72	18:00:00	1.48			7.73	05:20:00	1.47			-0.01
30GI113	46	9.20	8.20	17:59:00	1.00	0.48	0.01	8.18	05:18:00	1.02	0.45	0.01	0.02
11GS005	12	10.34	7.66	18:30:00	2.68			7.69	04:55:00	2.65			-0.03
11GI006	46.6	10.34	8.41	18:31:00	1.93	0.75	0.02	8.61	04:57:00	1.73	0.92	0.03	-0.20
11GS003	12.5	11.21	8.89	18:34:00	2.32			8.89	05:02:00	2.32			0
11GI004	47	11.45	8.94	18:35:00	2.51	-0.19	-0.01	9.06	05:03:00	2.39	-0.07	0	-0.12
11GS001	12.5	9.89	7.53	18:45:00	2.36			7.54	05:13:00	2.35			-0.01
11GI002	45.8	10.31	8.16	18:44:00	2.15	0.21	0.01	8.20	05:11:00	2.11	0.24	0.01	-0.04
11GS13	11	5.48	4.01	17:38:00	1.47			4.07	03:57:00	1.41			-0.06
11GI14	44.5	5.46	3.79	17:39:00	1.67	-0.20	-0.01	3.81	03:58:00	1.65	-0.24	-0.01	-0.02
11GS009	10.5	5.01	3.37	18:04:00	1.64			3.40	04:26:00	1.61			-0.13
11GI010	45	5.01	3.47	18:03:00	1.54	0.10	0	3.59	04:25:00	1.42	0.19	0.01	-0.12
11GS007	11	6.28	4.68	18:16:00	1.60			4.72	04:38:00	1.56			-0.04
11GI008	44	7.05	5.81	18:17:00	1.24	0.36	0.01	6.08	04:40:00	0.96	0.59	0.02	-0.27

Notes:
TOC El = top of casing elevation
ft msl = feet mean sea level
ft/ft = feet per foot

Table 1-5
Comparison of Groundwater Levels of the Upland Terrace Shallow/Intermediate Well Pairs

Well Pair ID	Total Depth (ft bgs)	Groundwater Elevation (ft msl)	Shallow - Intermediate (difference)	Vertical Gradient (ft/ft)
25GS08	22	5.69		
25GI02	50	4.46	1.23	0.04
27GS02	25	8.10		
27GI02	63	7.36	0.74	0.02
27GS11	24	7.89		
27GI06	57	7.25	0.64	0.02
27GS05	22.5	5.65		
27GI04	57	5.34	0.31	0.01
27GS04	22	6.22		
27GI01	54.5	5.73	0.49	0.02

Notes:
ft bgs = feet below ground surface
ft msl = feet mean sea level
ft/ft = feet per foot

1.4.4 Aquifer Characteristics

Specific capacity tests were conducted on many newly installed EnSafe wells to characterize the aquifer at these locations and depths. The geometric mean hydraulic conductivity for the shallow wells (upper surficial zone) was 167.7 ft/day; in intermediate wells just above the low-permeability zone clay, conductivities were significantly less, only 16.32 ft/day. The conductivity is lower in the intermediate wells due to an increase in fine-grained material as the surficial sands grade into the low-permeability clay. It is not known if this trend is characteristic of the entire base.

1.4.5 Surface Water Hydrology

Due to surface soil permeability at NAS Pensacola, channelized stream flow is rare. Historically water in Wetland 5A pooled because two beaver dams obstructed flow; seeps and springs on the northwest slope also contributed; as a result, Wetland 5A discharged year-round to Wetlands 5B, 6, and 7, and emptied to Bayou Grande. In conjunction with the Wetland 5A removal action in 1995, the two beaver dams were torn down. The area is now seasonally dry. OU 2 storm water runoff is intercepted by a network of ditches and drains that control floods on roadways and parking areas. All storm water eventually discharges to the wetlands or the bayou.

1.5 Nature and Extent and Baseline Risk Assessment Summary

In the RI, all compounds detected in soil and groundwater were compared with various screening criteria to determine potential risk to human health and the environment. Screening parameters are described below.

Soil

- Risk-based concentrations (RBCs), soil ingestion scenario for residential soil (surface soil), and soil screening levels (SSLs), transfer scenario from soil to groundwater (subsurface soil) (USEPA, 1996a).

- Selected Cleanup Goals (CGs), residential scenario (surface soil) and leaching scenario (subsurface soil) (FDEP, 1995 and 1996).

- USEPA, Office of Solid Waste and Emergency Response draft revised Interim Soil Lead Guidance (USEPA, 1994).

Groundwater

- Maximum Contaminant Levels (MCLs) (USEPA 1996b).
- Tap Water RBCs (USEPA, 1996a).
- Florida Primary Drinking Water Standards (FPDWS) (FDEP 1994a).
- USEPA Secondary Maximum Contaminant Levels (SMCLs) (USEPA 1996b).
- Florida Secondary Drinking Water Standards (FSDWS) (FDEP 1994a).
- Florida Groundwater Guidance Concentrations (FGGC) (FDEP 1994a).

Sediment

- Sediment Screening Values (SSVs) (USEPA, 1995).
- Sediment Quality Assessment Guidelines (SQAGs), Threshold Effects Levels (TELs) (FDEP, 1994b).

Soil and groundwater inorganics were compared with NAS Pensacola-specific reference concentrations (RCs), developed by the Navy during the Site 1 investigation. These are equal to twice the detected mean for any given parameter (E/A&H, 1996). The RCs can be found in Appendix A.

After constituents were compared with these screening criteria, a BRA was performed on RI data for each site. BRA results are summarized below.

1.5.1 Site 11

The source of contamination was identified to be a former landfill, where trenching revealed evidence of a "seam" of blackened debris at the water table. This oily material contained finely corroded bits of metal and other debris.

The BRA identified several soil inorganic Chemicals of Potential Concern (COPCs) at Site 11: arsenic, beryllium, cadmium, chromium, and iron. Soil organic COPCs include Aroclor-1260 and benzo(a)pyrene equivalents (BEQs). Groundwater inorganic COPCs include arsenic and beryllium. Groundwater organic COPCs include 1,2-dichloroethene (1,2-DCE), aldrin, chloroform, 1,2-dichloroethane (1,2-DCA), dieldrin, 1,1,2,2-tetrachloroethane, tetrachloroethene (PCE), trichloroethene (TCE), and vinyl chloride.

1.5.2 Site 12

Site 12 soil exceedances mainly included primary/secondary metals, polychlorinated biphenyls (PCBs), and semivolatile organic compounds (SVOCs). Storage of scrap metals contributes to metals contamination at this site. Though none were noted during the field investigation, previous storage of old transformers pending disposal is a possible contributor to the PCB contamination at Site 12. Residual fuel and oil from scrapped aircraft and vehicles stored at the site are possible sources of SVOCs at Site 12.

Arsenic, cadmium, and iron were identified at Site 12. Soil organic COPCs include Aroclor-1260 and BEQs. In addition, radium was found in soil samples at four times the 40 CFR 192.12 standard. COPCs identified in groundwater included Aroclor-1260, chloroform, 1,1-DCE, dieldrin, heptachlor epoxide, and PCE.

1.5.3 Site 25

Soil samples collected behind Building 780 revealed a wide range of primary/secondary metals and SVOC contamination. Shallow wells next to the building contained primary and secondary metals, and an adjacent intermediate well contained metals as well as chlorinated solvents, benzene and xylene. Improper storage and disposal of materials at Building 780 are possible sources of soil and groundwater contamination. Another location of concern at Site 25 is the storage yard behind Building 225, used as a metal prefabricating shop by the NAS Pensacola PWC. This yard contains racks of metal sheeting, piping, etc. Shallow and intermediate wells contained numerous primary and secondary metals exceedances, as well as PCE and TCE. Activities in and around this building are a possible source for contamination in these wells.

The BRA identified soil inorganic COPCs at Site 25 to include arsenic, beryllium, cadmium, chromium, and iron. Soil organic COPCs include Aroclor-1254, Aroclor-1260, BEQs, and dieldrin. All inorganic COPCs associated with the elevated hazard indices (above .01) in Site 25 groundwater were eliminated from the risk assessment based on comparison of Phase I and Phase II groundwater data. Groundwater organic COPCs include reported groundwater concentrations of chlorinated VOCs (1,1-DCE, chloroform, PCE, TCE, and vinyl chloride).

1.5.4 Site 26

No significant contamination was detected at Site 26. No inorganics contributed to risk in Site 26 soil; BEQs found in soil samples elevate the risk close to the 1E-06 threshold. Groundwater inorganic COPCs include arsenic, beryllium, and cadmium. Groundwater organic COPCs include dieldrin and PCE.

1.5.5 Site 27

Known as the Radium Dial Shop, Site 27 is on the remaining concrete foundation of former Building 709, which is currently a parking lot. At Site 27, SVOC exceedances were noted from wells previously installed by ABB, Inc., in support of UST removals at this location. The former USTs are possible contributors of contamination in these wells.

The BRA identified soil inorganic COPCs at Site 27 including aluminum, arsenic, cadmium, chromium, iron, and mercury. Soil organic COPCs included dieldrin and BEQs. In groundwater, chromium, iron and manganese contributed to a cumulative hazard index greater than one. Groundwater organic COPCs reported concentrations of chlorinated VOCs, including 1,4-dichlorobenzene, 1,1-DCE, 1,2-DCA, dieldrin, chloroform, PCE, and TCE, which are associated with risk projections ranging from 1E-06 to 6E-04.

1.5.6 Site 30

At Site 30, numerous former ABB, Inc. wells were associated with previous UST removals within the Building 649 complex, and revealed chlorinated solvents and benzene exceeding preliminary remediation goals (PRGs). E/A&H wells installed on the western side of this complex revealed

SVOC and VOC exceedances. Aboveground storage tanks at this complex, the former USTs, and associated buried piping are considered sources of this contamination. Several former ABB wells in and around Building 3220 exhibited benzene, chlorinated solvents, and phenol concentrations exceeding PRGs. Former ABB wells south of Building 3450 also exhibited phenol above PRGs. All of these wells were associated with former UST removals. A shallow well (30GS154) on the north side of Building 3450 exhibited vinyl chloride and xylene above PRGs.

The BRA identified soil inorganic COPCs at Site 30, including arsenic and beryllium. Soil organic COPCs included BEQs and PCBs. Groundwater inorganic COPCs were arsenic, cadmium and chromium. Groundwater organic COPCs include benzene, chloroform, 1,1-DCE, 1,4-dichlorobenzene, PCE, and 1,1,1-trichlorethane. In addition to noting the risk associated with UST removals in the Site 30 area of investigation, the BRA noted that groundwater concentrations of vinyl chloride contributed significantly to elevated risk at the location represented by monitoring well 30GS154.

Site 30 also includes a portion of the IWTP sewer. The intermediate well (30GI111) adjacent the southwest corner of Building 3189 exhibited chlorinated VOCs, benzene, iron, manganese, and sodium above PRGs. Activities at the former hazardous materials accumulation area likely contributed to this contamination. Samples from well 30GS103 installed in a fenced storage yard directly north of Building 3644 (a former NADEP building), contained primary/secondary metals contamination, as well as chlorobenzene. Nearby well 30GS101 contained xylene and benzene. The contamination in 30GS103 is likely attributable to NADEP activities at Building 3644. Well 30GS101 is adjacent to the former IWTP, and may be impacted by former IWTP activities. Chlorobenzene and toxaphene were detected at well 30GS123, near a lift station for the former IWTP sewer line. Past spills from this lift station are the suspected contributors of this contamination. The BRA found that groundwater concentrations of arsenic, benzene, 1,4-dichlorobenzene, and vinyl chloride contributed significantly to elevated risk, while chlorobenzene and iron contributed significantly to elevated hazard indices (greater than one) at the location represented by monitoring well pair 30GS111 and 30GI111. Other than 30GI111, the BRA only addressed soil boring 30S102 at this site,, north of the Building 3644 complex, reporting elevated risk concentrations for BEQs.

1.5.7 Radiological Investigations

Sites 25 and 27

A radiological investigation, conducted to explore possible near-surface radiation at Sites 25 and 27, revealed a loading dock at Site 25 where radium-paint had spilled. The contamination was confined to the concrete pavement and had been cleaned up. EnSafe conducted a surface survey and found no evidence of the spill.

At Site 27 radiation surveys revealed a small contaminated area south of former Building 709 where a spill had apparently occurred adjacent to an old stairway from Building 709. Outside this limited area, no significant soil radiological contamination was found anywhere on these sites.

Sites 12 and 26

EnSafe performed a preliminary radiological screening survey at Sites 12 and 26, which involved scanning the site for Ra-226 with a radiation survey meter. The entire surface area of both sites was scanned, with measurements recorded at the soil surface; additional measurements were obtained from contaminated locations at one meter above the ground. The investigation revealed radiological contamination in two locations in the north-central portion of Site 12, as well as a 15-foot by 50-foot area near the southeast corner of the site.

1.5.8 Potential Receptors

OU 2 has been an industrial area supporting supply, maintenance, and disposal activities for more than 40 years. The contaminants within OU 2 appear to be limited to surface and subsurface soils, the surficial aquifer, groundwater-to-surface water discharge, and areas where point source or non-point source storm water discharges occur (e.g., wetlands). Current and potential receptors include:

- The surficial zone of the Sand-and-Gravel Aquifer, which is currently not in use due to taste and odor characteristics.

- The main producing zone of the Sand-and-Gravel Aquifer, used as a potable water source in Escambia County, which underlies the surficial zone but is separated from it by a confining clay unit.

- NAS Pensacola Wetland 5A, which receives runoff from the southwestern portion of the OU 2 area (Site 30).

- NAS Pensacola Wetland 5B, which drains Wetland 5A to Wetland 6 (Sites 36, 25, and 27).

- The concrete-lined drainage ditch, also known as NAS Pensacola Wetland 6.

- The Yacht Basin, an arm of Bayou Grande, which receives runoff and groundwater flow from the areas of Sites 11, 12, 25, and 26.

The low-permeability clay layer between the surficial and main producing zones may inhibit any downward contaminant migration into the deeper groundwater below the clay. The coastal waters of surrounding NAS Pensacola have been classified by the FDEP as Class III, indicating their use for recreation and maintenance of a well-balanced fish and wildlife population. Potential ecological impacts on wetland areas adjacent to OU 2 will be addressed in separate upcoming RI/FSs for Bayou Grande (Site 40), and the NAS Pensacola Wetlands (Site 41).

1.5.9 RI Data Gaps and Recommendations

No data gaps were noted that require additional fieldwork or analysis to complete this investigation and provide the basis for the feasibility study. The soil data offer sufficient analytical quantitation and distribution to assess the nature and extent of contamination. Soil exceedances due to metals, pesticides, PCBs, and SVOCs represent a risk that will need to be addressed by the feasibility study. Metals represent the largest proportion of soil risk. No VOCs detected comprise any risk due to a soil exceedance. SVOCs and pesticide/PCB compounds represent a minor part of the cumulative soil risk.

Due to high turbidity, Phase I groundwater sampling data are inappropriate to evaluate nature and extent. However, Phase I data were used to focus Phase II sampling on the locations with the highest concentrations to verify their presence. Inorganics, SVOCs, and VOCs confirmed by Phase II sampling are to be addressed by the feasibility study. Phase II sampling confirmed the presence of inorganics, SVOCs, and VOCs to be addressed by the FS. These COCs exhibit a risk greater than 1E-6 and should be considered in the feasibility study. Three volatiles and two metals represent 90% of the risk to groundwater. Since no trend analysis is available, groundwater should be monitored quarterly before remedial design. The specific capacity used to calculate hydraulic conductivity is a rough order of magnitude estimate and should be amended with pumping tests to provide information during remedial design. The current pairing and distribution of monitoring wells appear to offer sufficient coverage to monitor trends effectively.

Because risk at Site 26 is below the 1E-06 threshold, no further action will be required at this site. This site was recommended for no further action in the RI. Groundwater is discussed in Section 8 because of its proximity to Sites 11 and 12.

The low-level radiological waste encountered at Sites 12 and 27 will be remediated by the Naval Sea Systems Command Radiological Affairs Support Office (RASO). RASO will be responsible for assessing, containing, packing, transporting, and disposing of any low-level radiological wastes. As a result, the FS will not be concerned with alternatives for low-level radiological wastes at these sites.

2.0 FEASIBILITY STUDY PROCESS

The overall objective of the CERCLA remedy selection process is to select remedies that are protective of human health and the environment, that maintain protection over time, and that minimize untreated waste. The RI is used to assess site conditions and the risk assessment process is used to assess risk and hazard based on RI findings. These data are used to gauge the magnitude of site risk and identify possible areas requiring feasibility study. At OU 2, Sites 11, 12, 25, 27, and 30 were recommended for FS.

The FS process comprises the following elements:

- **Development of Remedial Action Objectives (RAOs) and Remedial Goals (RGs)**, including the definition of applicable or relevant and appropriate requirements (ARARs) and development of RAOs, delineation of areas which exceed Rgs and require feasibility analysis, and associated impacted volumes.

- **Technology Screening**, including identification of remedial process options which address site contaminants, and evaluation against three basic screening criteria: implementability, effectiveness, and cost.

- **Assembly of Alternatives**, in which technologies deemed applicable to site conditions are assembled into viable remediation alternatives. A conceptual design is developed and evaluated again using the three basic screening criteria of implementability, effectiveness, and cost. This second screening process identifies advantages and disadvantages of each remedial approach.

- **Detailed Analysis of Alternatives**, including assessing each alternative against nine criteria specified in 40 CFR 430(e)(9)(iii) (the National Oil and Hazardous Substances

Contingency Plan [NCP]). These criteria are used to evaluate each alternative's overall protection of human health and the environment and compliance with statutory requirements.

- **Comparative Analysis of Alternatives**, which highlights the similarities and differences between the alternatives using the nine NCP criteria.

This section will outline the major elements of the FS process. Feasibility analysis will be performed for each individual site in the following sections:

- Section 3 — Site 11 Soil
- Section 4 — Site 12 Soil
- Section 5 — Site 25 Soil
- Section 6 — Site 27 Soil
- Section 7 — Site 30 Soil
- Section 8 — Sites 11, 12, and 26 Groundwater
- Section 9 — Sites 25, 27, and 30 Groundwater

2.1 Development of Remedial Action Objectives

The remedial alternatives selection process begins during RI planning, when PRGs are set, based on readily available information such as presence of chemical-specific ARARs. As the RI/FS proceeds, goals are modified as needed to reflect understanding of the site and its ARARs. Final remediation goals are established when the remedy is selected. The goals must establish acceptable exposure levels that are protective of human health and the environment, and must consider ARARs.

In developing remedial objectives for the FS, four issues were addressed:

- PRGs based on chemical-specific ARARs
- Spatial distribution of contamination in the media of concern, as determined by the RI
- Human health and ecological assessments, including exposure pathways, addressed in the BRA
- Potential groundwater contamination indicated by contaminant residuals in site soil

2.1.1 Chemical-Specific ARARs and To-Be-Considered Criteria (TBCs)

As per the NCP, remedial goals establish acceptable exposure levels that are protective of human health and the environment and are developed by considering the following:

- ARARs under federal environmental or state environmental or facility sitting laws, if available, and the following factors:
  - For systemic toxicants, acceptable exposure levels shall represent concentration levels to which the human population, including sensitive subgroups, may be exposed without adverse effects during a lifetime or part of a lifetime, incorporating an adequate margin of safety.
  - For known or suspected carcinogens, acceptable exposure levels are generally concentrations that represent an excess upper bound lifetime cancer risk between 1E-06 and 1E-04. The 1E-06 risk level shall be used as the point of departure for determining remediation goals for alternatives when ARARs are not available or

are not significantly protective due to the presence of multiple contaminants or exposure pathways.

— Technical limitations, quantiation limits, uncertainties, etc.

- Non-zero maximum contaminant level goals (MCLGs), established under the Safe Drinking Water Act (SDWA), are relevant and appropriate for ground or surface waters that are current or potential drinking water sources. When MCLGs are set at zero, maximum contaminant levels (MCLs) shall be attained when relevant and appropriate to the circumstances of the release.

- In cases involving multiple contaminants or pathways where attainment of chemical-specific ARARs will result in cumulative risk in excess of 1E-04, risk- or technology-based goals may be developed.

- Water quality criteria established under the Clean Water Act (CWA) shall be attained where relevant and appropriate.

- Alternate concentration limits (ACLs) may be established in accordance with CERCLA Section 121(d)(2)(B)(ii).

- Environmental evaluations shall be performed to assess threats to the environment.

Chemical-specific ARARs will be considered in developing remedial objectives for the site.

A review of potential ARARs, shown in Appendix A, identified potential site remediation goals in Florida Proposed Rule 62-777. This rule will be referenced by Florida Administrative Code

(FAC) 62-770 and 62-785, rules for underground storage tank (UST) and Brownsfields sites, respectively. Though not directly applicable to OU 2, these rules have been identified as relevant and appropriate to remedial actions at NAS Pensacola due to similar site contaminants and end-use objectives. As discussed in Proposed Rule 62-777, soil goals may include:

- Residential soil cleanup target levels (RSCTLs), where land use will be unrestricted

- Industrial soil cleanup target levels (ISCTLs), where land use will be restricted to industrial or commercial/industrial uses

- Soil leaching criteria protective of poor quality groundwater (SL-PQG)

- Soil leaching criteria protective of surface water (SL-SW) (marine or freshwater, as appropriate)

Proposed rule 62-777 identifies the following potential criteria for groundwater:

- FPDWS
- FSDWS
- Groundwater criteria protective of fresh surface water (FSWQ)
- Groundwater criteria protective of marine surface water (MSWQ)
- Groundwater criteria for poor quality groundwater (PQG)

FSWQ, MSWQ, and PQG standards were obtained from Proposed Rule 62-777. FSWQ and MSWQ standards were only evaluated when site groundwater could discharge directly to an adjacent surface water body.

Appendix C contains tables identifying all sample locations that exceed specific Florida criteria for soil and groundwater. As stated above, Appendix A lists chemical-, location-, and action-specific ARARs.

2.1.2 Definition of RAOs and RGs

RAOs are typically defined once the nature of site contaminants is known. In addition, current and future land use, adjacent property conditions, human health and ecological risk assessments, and other factors may be considered to identify a "reasonable future use" scenario. Identification of site COCs, as well as the future use scenario, enable decision-makers to develop site-specific RGs that are protective of human health and the environment, but which are not overly conservative given probable exposure scenarios.

2.1.3 Delineation of Areas Exceeding RGs

Once RAOs and RGs are defined, media exceeding RGs can be identified. At OU 2, the environmental media exceeding RGs are soil and groundwater. FDEP has required point-by-point compound-specific compliance with RGs; therefore constituents in each soil boring and groundwater monitoring well will be compared with RGs. Exceedances will be noted and the areas exceeding RGs will be defined.

2.1.4 Environmental Media Volumes Exceeding RGs

Where environmental media exceed RGs, volumes requiring remedial action will be estimated. These estimates will be developed using RI-generated data, and data gaps will be identified where volume estimates are uncertain. Accurate delineation of remedial volumes is critical to the selection of applicable remediation technologies, as well as development of reliable cost estimates.

2.2 Technology Screening

After impacted media volumes are defined, the next step in the FS process is identification of technologies applicable to site contaminants. Once technologies are identified, they are reviewed for effectiveness, implementability, and cost. Technologies are either eliminated or retained for further consideration. This screening is done on a site-by-site and media-specific basis for OU 2 because of the various contaminants identified and ongoing use requirements at the base.

2.2.1 CERCLA Response Actions

The NCP provides guidance for conducting the RI/FS and the process of remedy selection. The stated purpose of the selection process is to assure that implemented remedies protect human health and the environment by eliminating, reducing, and/or controlling risks posed through each pathway. The goal of the FS process is to select remedies based on fundamental criteria including:

- Protection of human health and the environment
- Compliance with ARARs
- Minimization of untreated hazardous waste

2.2.2 Program Management Principles

Sites should be remediated in OUs when 1) reduction of significant risk must be accomplished quickly, 2) a phased analysis and response is necessary or appropriate given the size or complexity of the site, or 3) when the expected final remedy must be expedited. Interim responses should not be inconsistent with implementation of the expected final remedy, nor should they preclude it. Site-specific data needs, alternate evaluation, and documentation of the selected remedy should reflect the scope and complexity of the site problems being addressed.

2.2.3 Expectations

In the NCP, USEPA broadly categorizes remedial action alternatives into general response actions for consideration in the FS.

- **Treatment** — Use treatment to address the principal threats posed by a site, where practical.

- **Containment** — Use engineering controls such as containment for waste that poses a relatively low long-term threat, or where treatment is impractical.

- **Combination** — Use a combination of appropriate methods to protect human health and the environment.

- **Land Use Controls** — Use institutional controls such as water and deed restrictions to supplement engineering controls as appropriate for short- and long-term management to prevent or limit exposure to hazardous substances, pollutants, or contaminants. Institutional controls will not be substituted for active response measures as the sole remedy unless such active measures are determined to be impractical, based on the balance of tradeoffs among alternatives determined during remedy selection.

- **Innovative Technology** — Consider innovative technology when it offers the potential for comparable or better treatment, performance, or ease of implementation, less adverse impacts, or lower costs than demonstrated technologies.

- **Groundwater Restoration** — Restore usable groundwater to its beneficial uses whenever practical, in a reasonable amount of time. Where this cannot be accomplished, USEPA expects to prevent further migration of the plume, prevent exposure to the contaminated groundwater, and evaluate further risk reduction.

2.2.4 General Response Actions

General response actions are media-specific actions that can achieve RAOs alone or in combination with other actions. Remedial action alternative types include:

- **Source Control Actions:** Source control actions are a range of alternatives in which treatment is used to reduce the toxicity, mobility, or volume of the hazardous substances, pollutants, or contaminants. The range considered in an FS should include an alternative that removes or destroys these constituents of concern to the maximum extent feasible, eliminating or minimizing the need for long-term management. In addition, alternatives are to be considered which treat the principal threats posed by the site, but vary in the degree of treatment and the amount and characteristics of residuals and untreated waste that must be managed.

- **Containment Actions:** One or more alternatives should be considered which protect human health and the environment primarily by preventing or controlling exposure to site contaminants through engineering or institutional controls. Examples include engineering controls such as extraction or injection wells and institutional controls such as deed or access restrictions.

- **Groundwater Response Actions:** A limited number of groundwater remediation actions should be assessed which attain site-specific goals within different restoration time periods. These alternatives should use one or more methods such as groundwater extraction, treatment and in-situ actions.

2.2.5 Identification of Technologies

This section provides general descriptions of technology types that may be applied to meet the response actions described above.

No Action/Limited Action

The NCP requires evaluation of a No Action alternative as a basis of comparison with other remedial alternatives. Because no action may result in contaminants remaining onsite, CERCLA, as amended, requires a review and evaluation of site conditions every five years if this alternative is selected.

Natural Attenuation

Natural attenuation refers to dilution, dispersion, advection, and biotic degradation of contaminants in the environment. Consideration of this option requires modeling and evaluation of contaminant degradation rates and transport during remedial design. Sampling and sample analysis must be conducted throughout the process to confirm that attenuation is proceeding at rates which meet remediation objectives and to assure that no receptors are threatened.

Institutional Controls

Institutional controls reduce potential hazards by limiting public exposure, not by reducing volume, mobility, or toxicity of hazardous substances. Some examples of such responses are:

- Site access controls
- Public awareness and education
- Groundwater use restrictions
- Long-term monitoring
- Deed restrictions
- Warning against excavation and soil use

Removal/Excavation

Removal includes excavating soil and collecting groundwater. Soil is excavated with heavy equipment. Collection of groundwater is achieved with subsurface drains (interceptor trenches/french drains) or groundwater extraction wells.

Containment

Groundwater is contained by installing a network of extraction wells or subsurface drains to produce a hydraulic barrier and eliminate or reduce the migration of groundwater. Vertical barriers such as slurry walls, high density polyethylene (HDPE) sheeting or sheet piling may also be used to reduce horizontal transport of contaminants in groundwater from the contaminated soil zones.

A surface cap of asphalt, concrete, clay, or synthetic membranes indirectly provides containment by minimizing contaminant transport through soil caused by percolation of precipitation. These containment options can be used alone or in combination to isolate contaminated soil and/or groundwater.

Treatment

Groundwater treatment technologies are varied, and include carbon adsorption, biological treatment, coagulation, precipitation, solids separation, stripping, oxidation/reduction, or photolysis. Soils may be treated by multiple technologies such as ex-situ biological degradation, low-temperature thermal desorption, incineration, or chemical/physical processes such asf soil washing, solidification, or stabilization.

Discharge/Disposal

Groundwater may be treated and discharged to the Federally-owned treatment works (FOTW), treated and discharged to surface water, or reinjected into the aquifer. Excavated soil may be disposed offsite at a hazardous or nonhazardous waste landfill, used as site fill material, or isolated in an onsite containment unit.

2.2.6 Preliminary Technology Screening

In the following sections, treatment technologies are presented for each site at OU 2. Groundwater from Sites 11, 12, and 26 and Sites 25, 26, and 30 is also assessed as two distinct managment units to facilitate technology screening and alternatives development.

After treatment technologies are defined, their objectives, implementability, effectiveness, and cost are discussed in terms of site specifics. The screening tables are consistent with technology screening techniques presented in the NCP and USEPA guidance because they include containment, removal, disposal, and treatment options. The three screening criteria applied to these technology options are implementability, effectiveness, and cost.

- Implementability encompasses both the technical and administrative feasibility of putting a technology into effect. Technical implementability is used to initially eliminate technology types and process options that are clearly ineffective or unworkable. The readily available information from the RI site characterization is used to screen out such methods. Administrative implementability emphasizes the institutional aspects of a remedy, such as the ability to obtain necessary permits for offsite actions; the availability of treatment, storage, and disposal services (including capacity); and the availability of necessary equipment and skilled workers to implement the technology.

- The effectiveness screening evaluation is based on how well each technology would protect human health and the environment. Each should be evaluated for its effectiveness in providing protection and reducing toxicity, mobility, or volume of contaminants. Both short and long-term components of effectiveness should be evaluated; short-term refers to the construction and implementation period and long-term refers to the period after the remedial action is complete.

- Costs play a limited role in the screening process. Relative capital and operation and maintenance (O&M) costs are used rather than detailed estimates. At this stage in the process, the cost analysis is based on engineering judgment, and each process is evaluated according to whether costs are high, low, or medium relative to other process options.

Following screening, technologies are either retained for assembly into alternatives or discarded. The rationale for discarding technologies is presented in each section.

2.3 Assembly of Alternatives

Following identification and screening of technologies, general response actions and process options are combined to form alternatives that address the entire site. These process options were chosen as representatives of technology types. In assembling alternatives, the NCP goal of evaluating a range of alternatives was considered. Where possible given the size of the site and the extent of RG exceedances, the alternatives vary in level of effort, balance of containment versus treatment measures, cost, and remediation time frame. Alternatives have been developed to respond separately to remedial needs for groundwater and soil.

Definitions of each alternative should provide sufficient information to distinguish the alternatives with respect to effectiveness, implementability, and cost. The following information should be included in each definition:

- Locations of areas to be excavated or contained.

- Approximate volumes of soil and/or groundwater to be managed.

- Size and configuration of onsite extraction and treatment systems or containment structures.

- Approximate locations of wells, trenches, treatment systems, etc.

- Management options for treatment residuals.

- For media with several hazardous constituents, it may be necessary to identify which contaminant(s) impose the greatest treatment requirements.

- Remediation time frame.

- Rates or flows of treatment.

- Spatial requirements for treatment or containment actions.

- Distances for disposal actions.

- Required permits for offsite actions and imposed limitations.

In short, the alternative description should include enough information to adequately explain the alternative and document the logic behind the proposed action.

After development, each alternative is screened again using the three general criteria of implementability, effectiveness, and cost.

- Implementability measures both the technical and administrative feasibility of constructing, operating, and maintaining an alternative. Technical feasibility refers to the ability to construct, operate, and meet ARARs, and includes an assessment of O&M and monitoring. Administrative feasibility refers to interactions with other agencies, availability of treatment, and any specific or unusual requirements.

- Effectiveness is evaluated through an assessment of how each alternative provides protection and the degree to which it reduces toxicity, mobility, or volume. Short-term effectiveness is evaluated according to the implementation period; long-term effectiveness assesses conditions after the remedial action is completed.

- Costs are assessed in greater detail at this stage than in the initial technology screening. A variety of cost-estimating data are considered to develop both capital and O&M costs.

2.4 Detailed Analysis of Alternatives

Once identified, remedial alternatives are evaluated with respect to the requirements stipulated in CERCLA as amended, the NCP (40 CFR 300.430), OSWER Directive Number 9355.9-19 (*Superfund Selection of Remedy*, Interim, December 24, 1986), and factors described in OSWER Directive Number 9355.3-01 (*Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, Interim Final, October 1988).

2.4.1 Evaluation Process

The detailed analysis of alternatives entails analyzing and presenting relevant information for decision-makers to select a site remedy; it is not intended to replace the decision-making process. During the detailed analysis, each alternative is assessed against the evaluation criteria described in the OSWER Directive Number 9355.3-01 and all other alternatives. The results of the assessment are arrayed to compare the alternatives and identify key tradeoffs among them. This approach to analyzing alternatives is designed to provide decision-makers with sufficient information to adequately compare the alternatives, select an appropriate site remedy, and demonstrate satisfaction of the CERCLA remedy selection requirements of the remedial action decision.

Nine evaluation criteria have been developed to address the CERCLA requirements and considerations, and to address the additional technical and policy considerations that have proven important for selecting among remedial alternatives. These evaluation criteria serve as the basis for conducting the detailed analysis during the FS and for subsequently selecting an appropriate remedial action.

Evaluation Criteria

- Overall protection of human health and the environment
- Compliance with ARARs
- Short-term effectiveness
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume
- Implementability
- Cost
- State acceptance
- Community acceptance

Each alternative is evaluated according to the above criteria, as described in the following sections. At the completion of all detailed analyses, a section is included in which the statutory factors and criteria listed above are compared for each alternative to assist in selecting a remedy.

2.4.2 Threshold Criteria

Alternatives must meet two threshold criteria to be considered in the FS: overall protection of human health and the environment, and compliance with ARARs.

Overall Protection of Human Health and the Environment

This criterion provides a final check of the alternative's ability to protect human health and the environment. The overall assessment of protection draws on the assessments conducted under other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

This evaluation step should focus on whether the alternative adequately eliminates, reduces, or controls the risk posed by each pathway through treatment, engineering, or institutional controls. This evaluation also considers whether an alternative poses any unacceptable short-term or cross-media impacts.

Compliance with ARARs

This criterion determines whether each alternative will meet all federal and state ARARs. The detailed analysis should identify which requirements are applicable or relevant and appropriate to an alternative, including chemical-, location-, and action-specific ARARs. The actual determination of which requirements are applicable or relevant and appropriate is made by the lead agency (the Navy) in consultation with the support agencies (USEPA and FDEP). Appendix A presents the ARARs for OU 2.

2.4.3 Balancing Criteria

Five balancing criteria highlight technical and administrative distinctions between each alternative. These five criteria include short-term effectiveness; long-term effectiveness; reduction of toxicity, mobility, or volume; implementability; and cost.

Short-Term Effectiveness

Short-term effectiveness addresses the effect of the alternative on human health and the environment during implementation, as determined by:

- Risks to the community.
- Risks to workers.
- Potential for adverse environmental impact.
- Time until remedial response objectives are achieved.

Long-Term Effectiveness and Permanence

This criterion addresses the risk remaining onsite after response objectives have been met. The primary focus in this step is the extent and effectiveness of the controls that may be required to manage the risk posed by treatment residuals and/or untreated wastes. The following should be addressed for each alternative:

- **Magnitude of Residual Risk:** This factor assesses risk remaining from untreated waste or treatment residuals at the conclusion of remedial activities. The potential for this risk may be measured by numerical standards such as cancer risk levels or the volume or concentration of contaminants in waste, media, or treatment residuals.

- **Adequacy and Reliability of Controls:** This factor assesses the adequacy and suitability of any controls that are used to manage treatment residuals or untreated wastes remaining onsite. This may include an assessment of containment systems and institutional controls to determine if they are sufficient to ensure that any exposure to human and environmental receptors is within protective levels.

Reduction of Toxicity, Mobility, or Volume

This criterion addresses the statutory preference for remedies that employ treatment technologies which permanently and significantly reduce the toxicity, mobility, or volume of the hazardous substances. The evaluation should consider the following specific factors:

- Treatment processes, the remedies they will employ, and the materials they will treat.
- Amount of hazardous materials that will be destroyed or treated, including how principal threat(s) will be addressed.
- Degree of expected reduction in toxicity, mobility, or volume, measured as a percentage of reduction (or order of magnitude) when possible.
- Degree to which the treatment will be irreversible.
- Type and quantity of treatment residuals that will remain following treatment.
- Whether the alternative would satisfy the statutory preference for treatment as a principal element.

Implementability

Implementability addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required to do so. Technical feasibility should consider:

- **Construction and Operation:** This factor assesses the technical difficulties and unknowns associated with constructing and operating a technology.

- **Reliability of Technology:** The likelihood that technical problems during implementation will lead to schedule delays.

- **Ease of Undertaking Remedial Actions:** Future remedial actions that may need to be undertaken and the difficulty in implementing them.

- **Monitoring Considerations:** The ability to monitor the effectiveness of the remedy, including evaluating exposure risks if monitoring is insufficient to detect a system failure.

The administrative feasibility of each alternative should also be considered, including all activities needed to coordinate with other offices and agencies.

- **Offsite Treatment:** Availability of adequate offsite treatment, storage capacity, and disposal services.

- **Equipment and Specialists:** Availability of necessary equipment and specialists, and provisions to ensure any necessary additional resources.

- **Services and Materials:** Availability of services and materials, plus the potential for obtaining competitive bids, which may be particularly important for innovative technologies.

- **Prospective Technologies:** Availability of prospective technologies.

Cost

Detailed cost estimates for each remedial alternative are based on engineering analyses, suppliers' estimates of necessary technology, and costs for similar actions (such as excavation) at other

CERCLA and Resource Conservation and Recovery Act (RCRA) sites. This is one of the primary balancing criteria on which the detailed analysis is based. The cost estimate for a remedial alternative includes capital cost, O&M costs, and present-worth analysis.

- **Capital Costs:** These typically include direct costs for equipment, labor, and materials used to develop, construct, and implement a remedial action. They also include indirect costs for engineering, financial, and other services that are not actually part of construction, but are required to implement the alternative. The percentage applied to the direct cost varies with the degree of difficulty associated with construction and/or implementation of the alternative. In this FS, indirect costs include health and safety items, permitting and legal fees, bid and scope contingencies, engineering design and services, and other miscellaneous supplies or costs.

- **Annual O&M Costs:** These are postconstruction costs necessary to ensure the continued effectiveness of a remedial action. They typically refer to long-term power and material costs (such as the operational cost of a water treatment facility), equipment replacement costs, and long-term monitoring and reporting costs.

- **Present-Worth Analysis:** This allows for comparison of remedial alternatives on the basis of a single cost representing an amount that, if invested in the base year and disbursed as needed, would be sufficient to cover all costs associated with the remedial action during its planned life. A performance period appropriate to each alternative is assumed for present-worth analyses. Discount rates of 6% are assumed for base calculations. An increase in the discount rate decreases the present worth of the alternative.

Cost elements for each remedial alternative are summarized in the cost analysis section. Study estimate costs are intended to reflect actual costs with an accuracy of minus 30% to plus 50%, in accordance with USEPA guidelines.

2.4.4 Modifying Criteria

Two modifying criteria, state and community acceptance, are used to evaluate the public's response to each alternative.

USEPA/State Acceptance

This assessment evaluates the technical and administrative issues and concerns USEPA and FDEP may have regarding each alternative. This criterion is largely satisfied through federal and state involvement in the remedial process, including review of the FS. The U.S. Navy, the lead agency, will work with USEPA and FDEP to implement the chosen alternative.

Community Acceptance

This assessment evaluates issues and concerns the public may have regarding each of the alternatives. As with state acceptance, this criterion will be addressed in the Record of Decision (ROD) when comments on the FS have been received.

2.5 Comparative Analysis of Alternatives

Once the alternatives have been fully described and individually assessed against the nine criteria, the relative performance of each is evaluated. The purpose of the comparative analysis is to identify the advantages and disadvantages of each alternative in relation to one another. This section should highlight differences between alternatives as they meet each of the criteria, especially the balancing criteria. This focus should help determine which options are cost-effective and which remedy utilizes permanent solutions and treatment to the maximum extent practicable.

3.0 SITE 11 SOIL FEASIBILITY EVALUATION

3.1 Site Description and History

The North Chevalier Field Disposal Area, Site 11, is a former landfill where industrial and municipal wastes were disposed of and burned from the late 1930s to the mid-1940s. The area occupies approximately 20 acres next to an arm of Bayou Grande called the Yacht Basin, north of former Chevalier Field. Surface elevations on the site are approximately 5 feet msl and topography slopes gently eastward toward Bayou Grande. Water level elevations range from 1 to 3 feet msl. Two prefabricated buildings, Buildings 3627 and 3628, are near the center of the site. Building 3445, at the site's southeastern corner, is used to store outdated office equipment. A fenced area north and south of Building 3445 is used for outside storage of boats, trucks, and heavy equipment. Pat Bellinger Road runs north-south through the site's center.

No removal actions have occurred at Site 11 after completion of the RI.

3.1.1 Site 11 Surface Soil Comparison with RSCTLs

Nine out of 18 locations exceeded one or more RSCTL, as shown in Table 3-1. These locations are widely spaced, with intervening distances sometimes exceeding 300 feet, as shown on Figure 3-1. Contaminants vary from location to location, suggesting that sources are discrete across the site (instead of impacting the entire site). If the extent of contamination is assumed to be limited to a 100- by 100-square foot area around each sample location to a depth of 2 feet below ground surface (bgs), then a total of 6,700 CY of surface soil are impacted in the Site 11 area.

3.1.2 Site 11 Comparison with ISCTLs

Four locations exceeded one or more ISCTLs, as shown in Table 3-2. Contaminants exceeding industrial standards included arsenic, chromium, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene. The locations are concentrated in the southern portion of the site, as

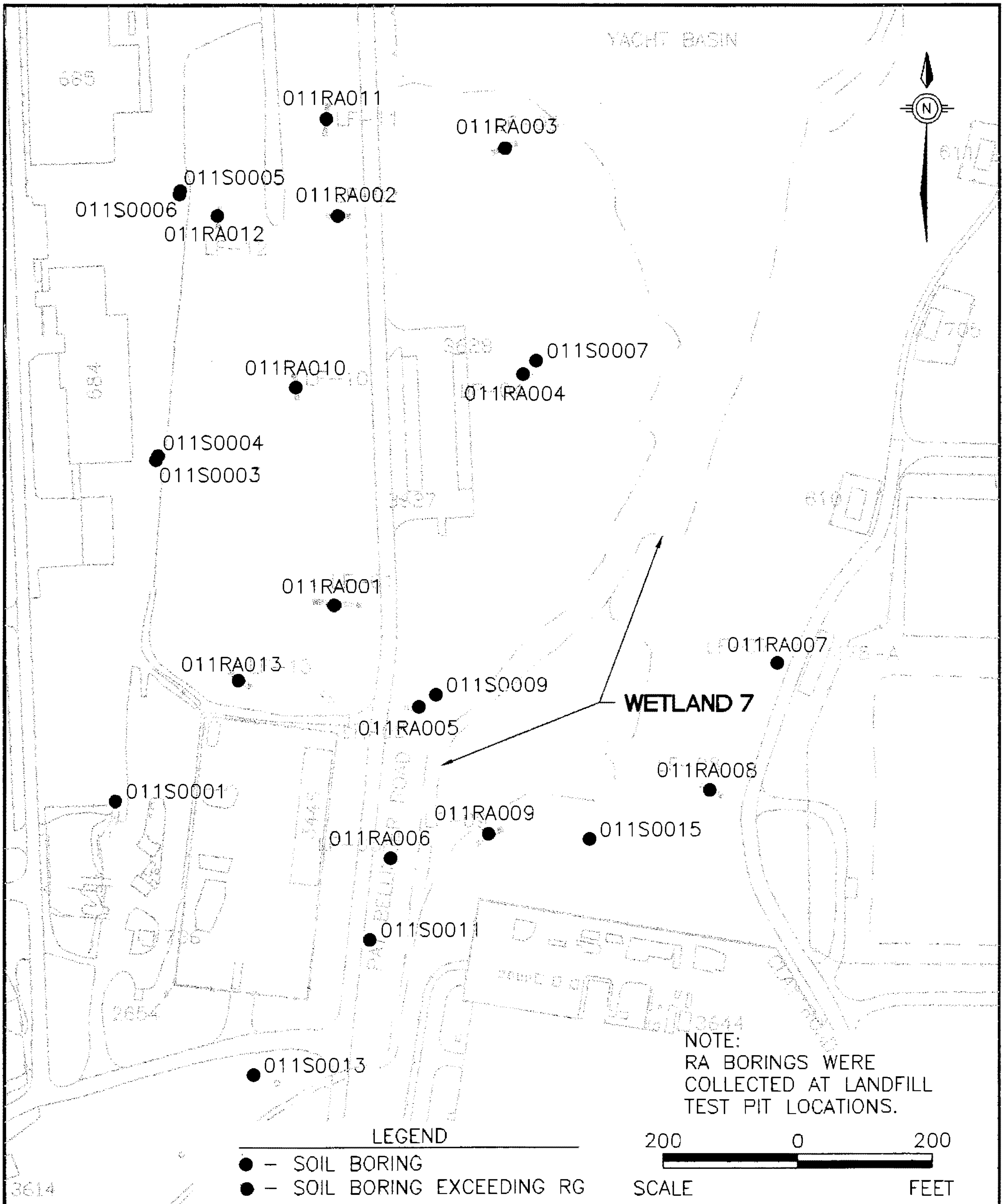


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FIGURE 3–1
SITE 11
SOIL BORING LOCATIONS
LOCATIONS EXCEEDING ONE OR
MORE RSCTLs

DWG DATE: 04/21/99	DWG NAME: 0059B006

Table 3-1
Site 11 Surface Soil Locations Exceeding RSCTLs

Location	Contaminant	Concentration (in mg/kg)
011-S-S001-01	Arsenic	3.0
	Benzo(a)pyrene	0.29 J
011-S-S003-01	Arsenic	1.9 J
011-S-S011-01	Arsenic	4.1 J
011-S-S013-01	Arsenic	2.7 J
011-S-RA05-01	Chromium	1,610 J
	Lead	760 J
011-S-RA06-01	Chromium	305 J
	Aroclor 1260	1.4 D
011-S-RA07-01	Benzo(a)anthracene	4.6
	Benzo(a)pyrene	4.5
	Benzo(b)fluoranthene	5.2
	Dibenz(a,h)anthracene	1.2 J
	Indeno(1,2,3-cd)pyrene	2.4
011-S-RA08-01	Chromium	413 J
	Benzo(a)pyrene	0.61 J
	Dibenz(a,h)anthracene	0.21 J
011-S-RA12-01	Chromium	488
011-S-RA13-01	Chromium	463 J

Notes:
RSCTLs may be found in Appendix C.
J = Concentration is estimated.
D = Concentration was obtained from a diluted sample.
mg/kg = milligrams per kilogram

shown in Figure 3-2. Each point is widely spaced, with at least 100 feet between adjacent sample locations. Contaminants are not consistent from location to location. If the extent of contamination is assumed to be limited to a 100- by 100-square foot area around each sample point, to a depth of 2 feet bgs, then a total of 3,000 CY of surface soil are impacted in the Site 11 area.

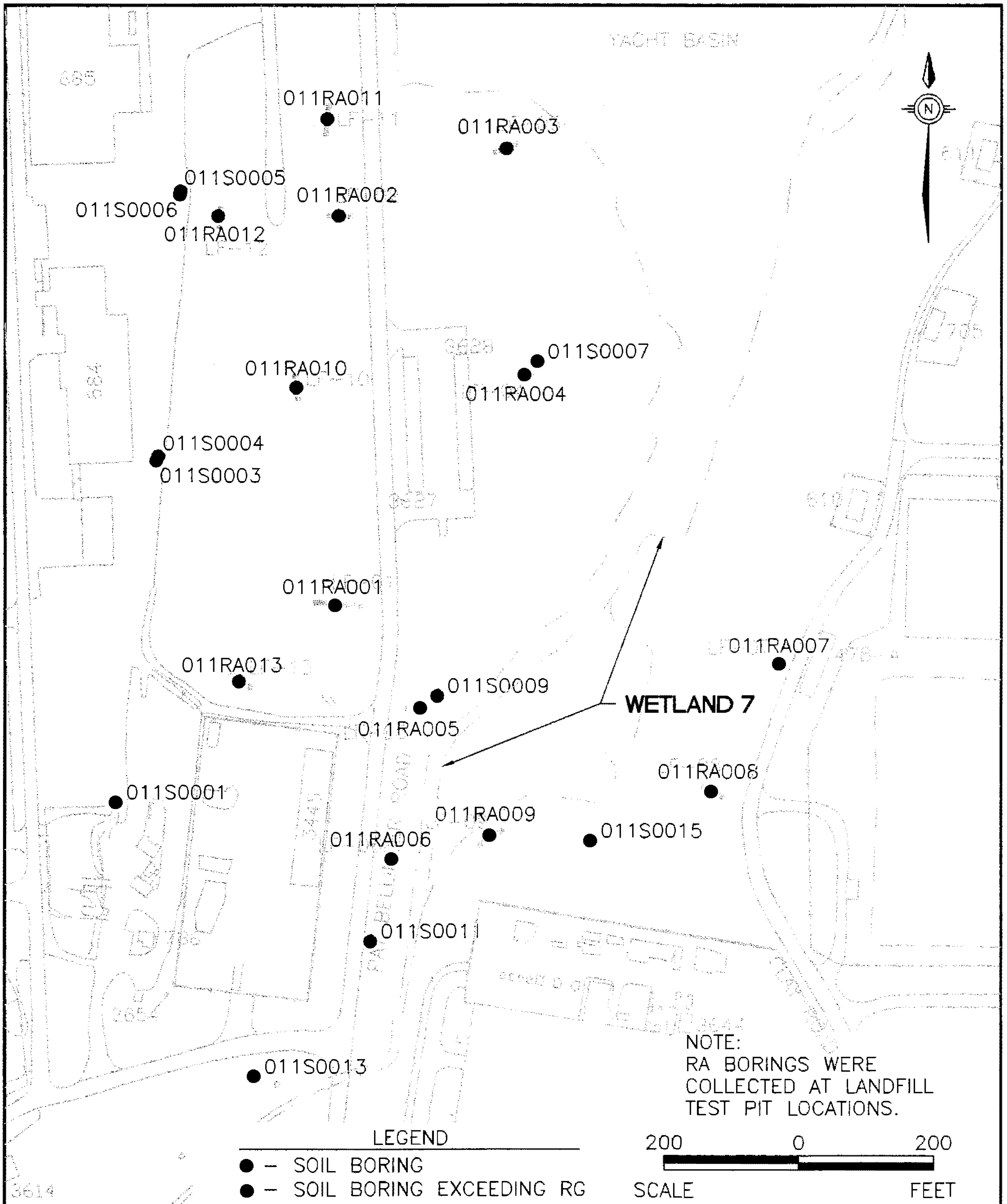

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FIGURE 3–2
SITE 11
SOIL BORING LOCATIONS
LOCATIONS EXCEEDING ONE OR MORE ISCTLs

DWG DATE: 04/21/99 | DWG NAME: 0059B005

Table 3-2
Site 11 Surface Soil Locations Exceeding ISCTLs

Location	Contaminant	Concentration (in mg/kg)
011-S-S011-01	Arsenic	4.1 J
011-S-RA05-01	Chromium	1,610 J
011-S-RA07-01	Benzo(a)anthracene	4.6
	Benzo(a)pyrene	4.5
	Benzo(b)fluoranthene	5.2
	Dibenz(a,h)anthracene	1.2 J
	Indeno(1,2,3-cd)pyrene	2.4
011-S-RA08-01	Chromium	413 J
	Benzo(a)pyrene	0.61 J
	Dibenz(a,h)anthracene	0.21 J

Notes:
ISCTLs may be found in Appendix C.
J = Concentration is estimated.
mg/kg = milligrams per kilogram.

3.1.3 Site 11 Comparison with Leaching Values Protective of Groundwater

As discussed in Section 1.3.3, groundwater from NAS Pensacola background wells exceeds primary and secondary standards, indicating that it may be classified as groundwater of poor quality. The leaching potential for site soil was therefore evaluated using SL-PQG criteria; exceedances are shown in Table 3-3 and on Figure 3-3. The primary exceedances detected in soil were cadmium, chromium, alpha-BHC, 2,6-dinitrotoluene, vinyl chloride, and xylene. However, of these compounds, only cadmium, chromium, and vinyl chloride were detected in groundwater at concentrations above GW-PQG criteria. These data indicate that other contaminants in soil are not appreciably leaching to groundwater.

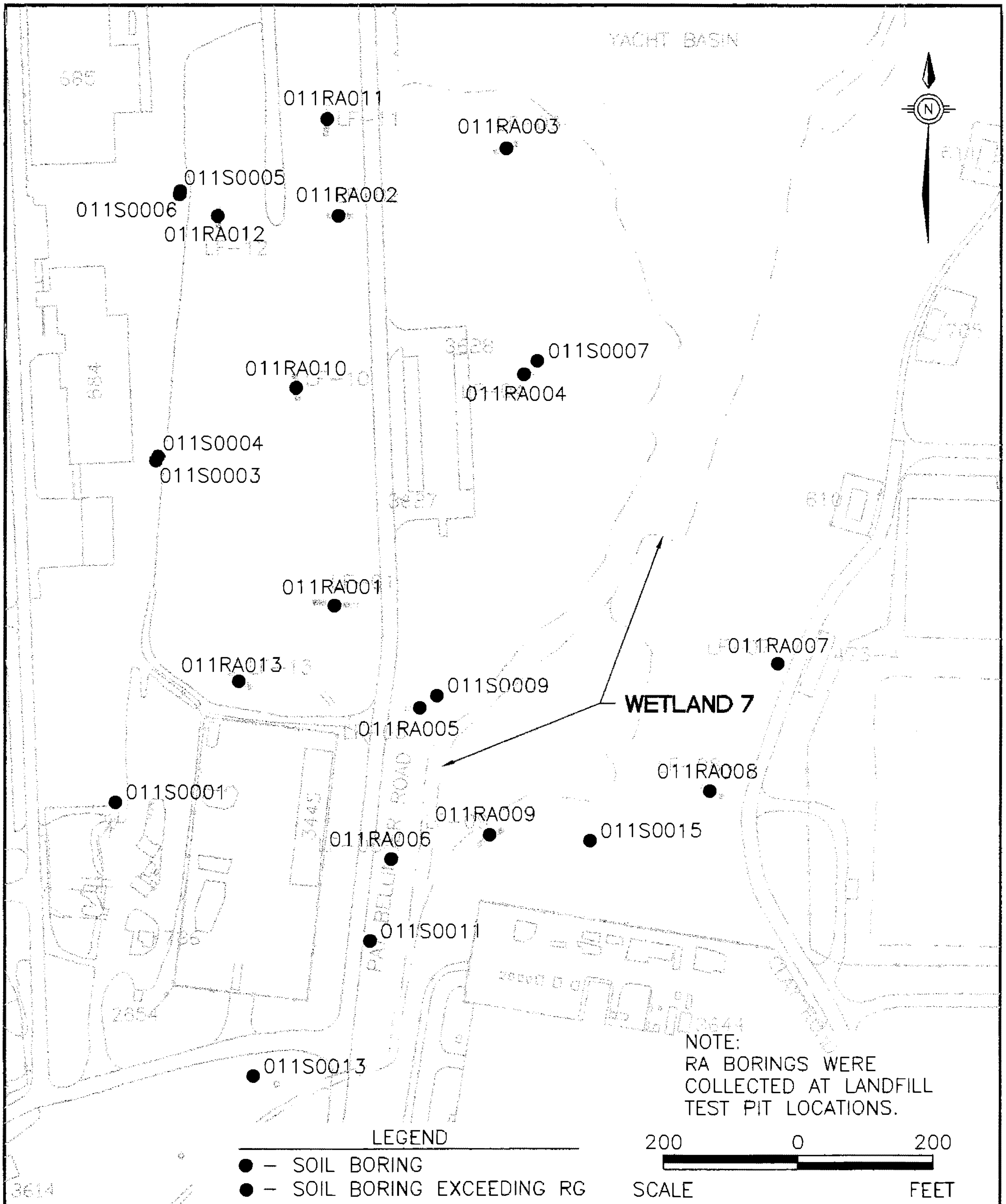

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FIGURE 3–3
SITE 11
SOIL BORING LOCATIONS
LOCATIONS EXCEEDING ONE OR MORE SL–PQG CRITERIA

DWG DATE: 04/21/99 | DWG NAME: 0059B007

Table 3-3
Site 11 Locations Exceeding SL-PQGs

Location	Contaminant	Concentration (in mg/kg)
011-S-S003-04	2,6-Dinitrotoluene	0.15 J
011-S-S003-06	2,6-Dinitrotoluene	0.17 J
011-S-RA05-01	Chromium	1,610 J
011-S-LF04-05	Cadmium	86.9 J
	Vinyl Chloride	0.079
011-S-LF10-06	Cadmium	129
011-S-LF12-06	Xylene	19
011-S-LF30-08	alpha-BHC	0.0037 J

Notes:
SL-PQG may be found in Appendix C.
J = Concentration is estimated.
mg/kg = milligrams per kilogram

Cadmium was present in two test pit locations, LF-04 and LF-10, at concentrations exceeding the SL-PQGs. Cadmium-contaminated groundwater was quantified in LF-10 and two other test pits above GW-PQG criteria; however cadmium was not detected above these criteria in permanent monitoring wells across the site. This discrepancy suggests that the test pit water samples may have been biased high due to entrained sediment, or other anomalies associated with sampling free liquids in a test pit. It is more likely that cadmium is characteristic of landfill leachate and relatively immobile. Because monitoring wells do not indicate significant contamination, cadmium contamination in soil will not be considered a potential threat to groundwater.

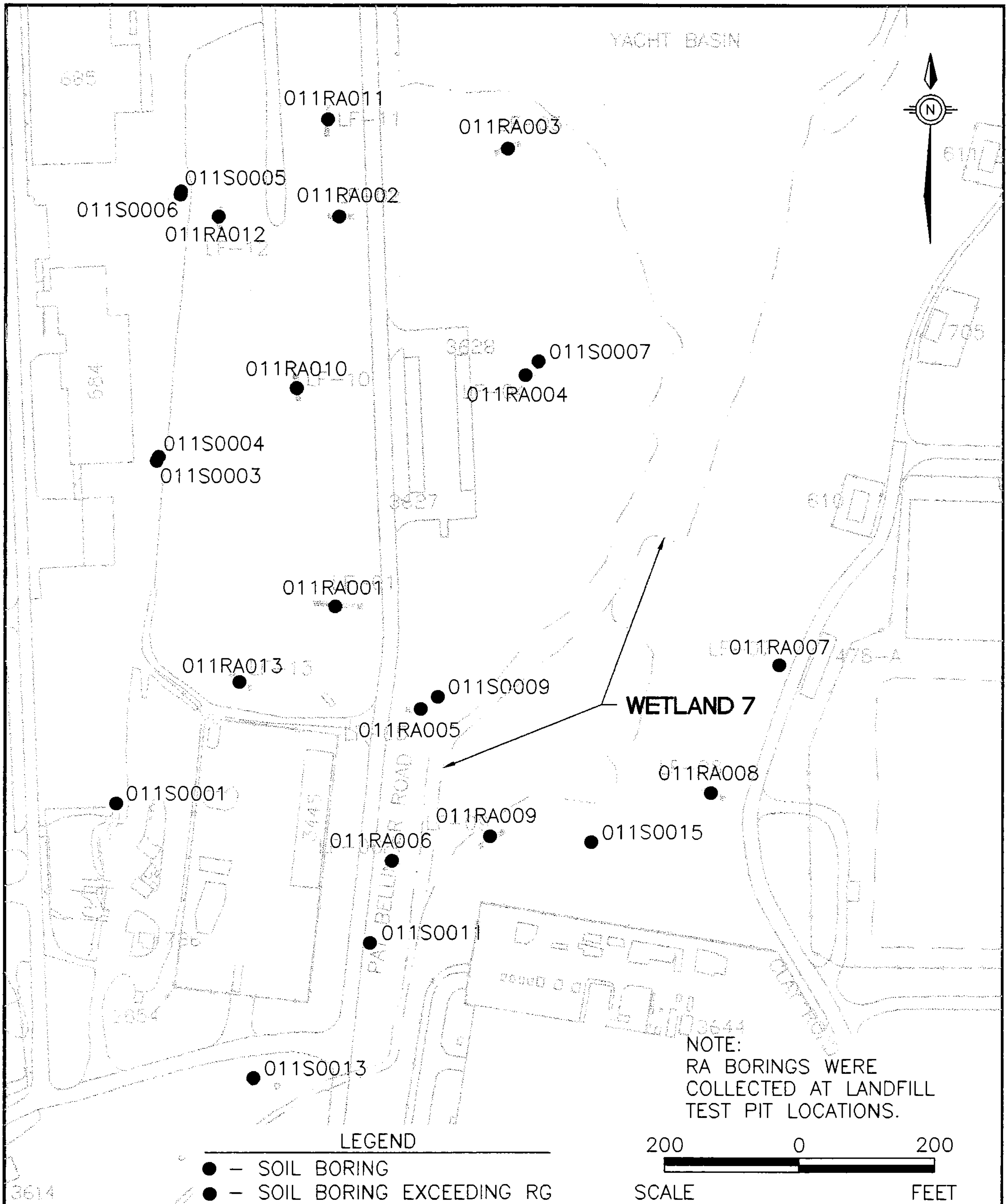
Similarly, chromium exceeded SL-PQG criteria in one soil sample, 011-S-RA05. Chromium was detected in groundwater samples from multiple test pits, including LF-10 and LF-11, at concentrations above GW-PQG criteria. As with cadmium, chromium was not detected above these criteria in permanent monitoring wells sitewide. This discrepancy suggests that test pit water samples may have been biased high due to entrained sediment, or other anomalies associated with sampling free liquids in a test pit. It is more likely that chromium is characteristic of landfill leachate and relatively immobile. Because monitoring wells do not indicate significant contamination, chromium contamination in soil will not be considered a potential threat to groundwater.

Vinyl chloride was quantified in one test pit location, LF-12, at 79 micrograms per kilogram (μg/kg), which is slightly above the SL-PQG criteria of 70 μg/kg. Although vinyl chloride was detected in multiple wells across Site 11, including GS-47, GS-52, and GI-14, only GS-47 is directly downgradient of the test pit. Well GS-28, located between GS-47 and LF-12, does not exhibit contamination above the GW-PQG criterion, suggesting that the test pit is not a primary source for vinyl chloride in groundwater. It is likely, given the age of the site and the history of adjacent activities, that the soil source for vinyl chloride is no longer distinguishable. Therefore, vinyl chloride in groundwater will be addressed in Section 8 as a groundwater issue. Because vinyl chloride contamination in LF-12 is not a likely threat to groundwater; it will not be considered a leachability problem.

3.1.4 Site 11 Comparison with Leaching Values Protective of Water Bodies

Several contaminants detected in site soil exceeded SL-SW criteria. Marine criteria were assessed because Site 11 abuts the Yacht Basin. Exceedances are identified in Table 3-4, and shown on Figure 3-4.

Compounds exceeding criteria included: DDE, DDT, Aroclor 1260, dieldrin, alpha-BHC, gamma-BHC, 2,6-dinitrotoluene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, naphthalene, phenanthrene, and xylene. Of these compounds, only dieldrin, naphthalene, and xylene were detected in groundwater, indicating that the remaining compounds were not leaching appreciably to groundwater.



SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND

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FIGURE 3–4
SITE 11
SOIL BORING LOCATIONS
LOCATIONS EXCEEDING ONE OR MORE MARINE SL–SW CRITERIA

DWG DATE: 04/21/99 | DWG NAME: 0059B004

Table 3-4
Site 11 Locations Exceeding SL-SWs

Location	Contaminant	Concentration (in mg/kg)
011-S-S001-01	Dieldrin	0.0065
011-S-S003-04	2,4-Dinitrotoluene	0.15 J
011-S-S003-06	2,4-Dinitrotoluene	0.17 J
011-S-RA05-01	Dieldrin	0.022
011-S-RA06-01	Aroclor 1260	1.4 D
011-S-RA07-01	DDE	0.19 DJ
	Benzo(a)anthracene	4.6
	Benzo(a)pyrene	4.5
	Benzo(b)fluoranthene	5.2
011-S-LF01-01	Benzo(a)anthracene	0.96 J
011-S-LF03-03	Benzo(a)anthracene	7.4
	Benzo(a)pyrene	4.5 J
	Benzo(b)fluoranthene	57
	Chrysene	6.1
	Phenanthrene	11
011-S-LF05-03	Benzo(a)anthracene	1.1 J
	Phenanthrene	4.3
011-S-LF07-07	DDE	0.23 D
	DDT	2.8 D
011-S-LF10-06	Benzo(a)anthracene	1.4
011-S-LF12-06	Naphthalene	1.4 J
	Xylene	19
011-S-LF30-08	Dieldrin	0.026 J
	alpha-BHC	0.0037 J
	gamma-BHC	0.606 J

Notes:
SL-SW may be found in Appendix C.
J = Concentration is estimated.
D = Concentration was obtained from a diluted sample.
mg/kg = milligrams per kilogram

Groundwater results for dieldrin, naphthalene, and xylene were reviewed to determine if they exceeded marine surface water quality criteria. Of these, only naphthalene was present above GW-SW criteria, indicating that the other compounds were not a threat to surface water quality.

Naphthalene was identified in landfill test pit LF-12. Naphthalene was also detected in downgradient well GS-47, between the landfill and the Yacht Basin, at concentrations ranging between 47 and 60 micrograms per liter (μg/L). These concentrations are somewhat above the GW-SW criteria of 26 μg/L. However, because concentrations are so low and the well is approximately 100 feet from the shoreline, attenuation is expected to reduce contaminant concentrations to below water quality standards before discharge into the Yacht Basin occurs. Therefore, naphthalene contamination in soil will not be considered a potential threat to groundwater.

Dieldrin, naphthalene, and xylene were detected infrequently in Wetland 64 sediments (at least one of these was detected in six out of 24 sediment sample locations). Typically these three contaminants contributed less than 5% of the total hazard at each sample location, suggesting that Site 11 is not a primary source of wetland contamination. The *Final Site 41 Remedial Investigation Report* (EnSafe, in press) indicated the primary contributor to wetlands contamination may be storm water runoff, not groundwater infiltration. As a result, Site 11 soil and groundwater will not be considered a potential threat to adjacent water bodies. Contaminated sediments identified in Wetland 64 will be addressed during the Site 41 action

3.2 Site 11 Remedial Goals

RGs for OU 2 have been proposed for the protection of human health and the environment given current and future land use. OU 2 has historically been used for industrial purposes, as described in Section 1; future use is expected to remain the same. Future risk to human health will be minimized by maintaining OU 2 as an industrial site. Institutional controls will be required for both soil and groundwater to limit exposures above appropriate criteria.

RAOs

- Protect the health of current and future site workers. ISCTLs will be used as RGs.
- Protect the environment by ensuring future soil-to-groundwater transfers are protective of a poor quality aquifer. SL-PQG criteria will be used to determine risks to the underlying aquifer.

3.2.1 Surface Soil Remediation Goals

Surface soil RGs are based on ISCTLs, as land use conditions are not expected to change. Table 3-5 presents the RGs for surface soil at Site 11; only compounds exceeding an RG are shown in this table.

Table 3-5
Contaminant-Specific Remediation Goals for Surface Soil at Site 11

Contaminant	RG (in mg/kg)
Arsenic	3.7
Chromium (VI)	420
Benzo(a)anthracene	5
Benzo(a)pyrene	0.5
Benzo(b)fluoranthene	4.8
Dibenz(a,h)anthracene	0.5
Indeno(1,2,3-cd)pyrene	5.3

Note:
mg/kg = milligrams per kilogram

3.2.2 Subsurface Soil Remediation Goals

Based on a comparison of site analytical data with Florida SL-PQG criteria, as discussed in Sections 3.1.3 and 3.1.4, contamination detected above SL-PQG and SL-SW criteria does not represent a current or potential source of groundwater contamination: there is no distinguishable source mass for site contaminants. Therefore, no subsurface remediation goals have been established for Site 11.

3.2.3 Soil Volumes

Table 3-6 identifies locations exceeding one or more ISCTLs. This table also identifies surface soil conditions and impacted soil volumes associated with each location.

Table 3-6
Site 11 Surface Soil Volumes Exceeding RGs

Location	Contaminant	Concentration (in mg/kg)	Comment	Volume
011-S-S011-01	Arsenic	4.1 J	Exposed surface soil	Irregular; total area 7,875 square feet; total volume 580 CY.
011-S-RA05-01	Chromium	1,610 J	Exposed surface soil	Assume 60 ft by 100 ft by 2 ft. Total volume 440 CY.
011-S-RA07-01	Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Dibenz(a,h)anthracene Indeno(1,2,3-cd)pyrene	4.6 4.5 5.2 1.2 J 2.4	Exposed surface soil	Assume 100 ft by 100 ft by 2 ft. Total volume 740 CY.
011-S-RA08-01	Chromium Benzo(a)pyrene Dibenz(a,h)anthracene	413 J 0.61 J 0.21 J	Exposed surface soil	Assume 100 ft by 100 ft by 2 ft. Total volume 740 CY.

Notes:
mg/kg = milligram per kilogram
J = Concentration is estimated
ft = foot
CY = cubic yard

The total soil volume impacted at Site 11 is approximately 2,960 CY. One location from Site 30 (030-S-0102), discussed in Section 7, is adjacent to impacted media at Site 11; this location also exceeds ISCTLs for benzo(a)pyrene and dibenz(a,h)anthracene. Because contaminants are similar to those identified in 011-S-RA08 and 011-S-RA07, soil boring 030-S-0102 will therefore be included in the remedial alternative assessment. By combining locations 030S0102 and 011SRA08, total soil volumes increase to 4,140 CY.

The areal distribution of contaminated media is shown in Figure 3-5.

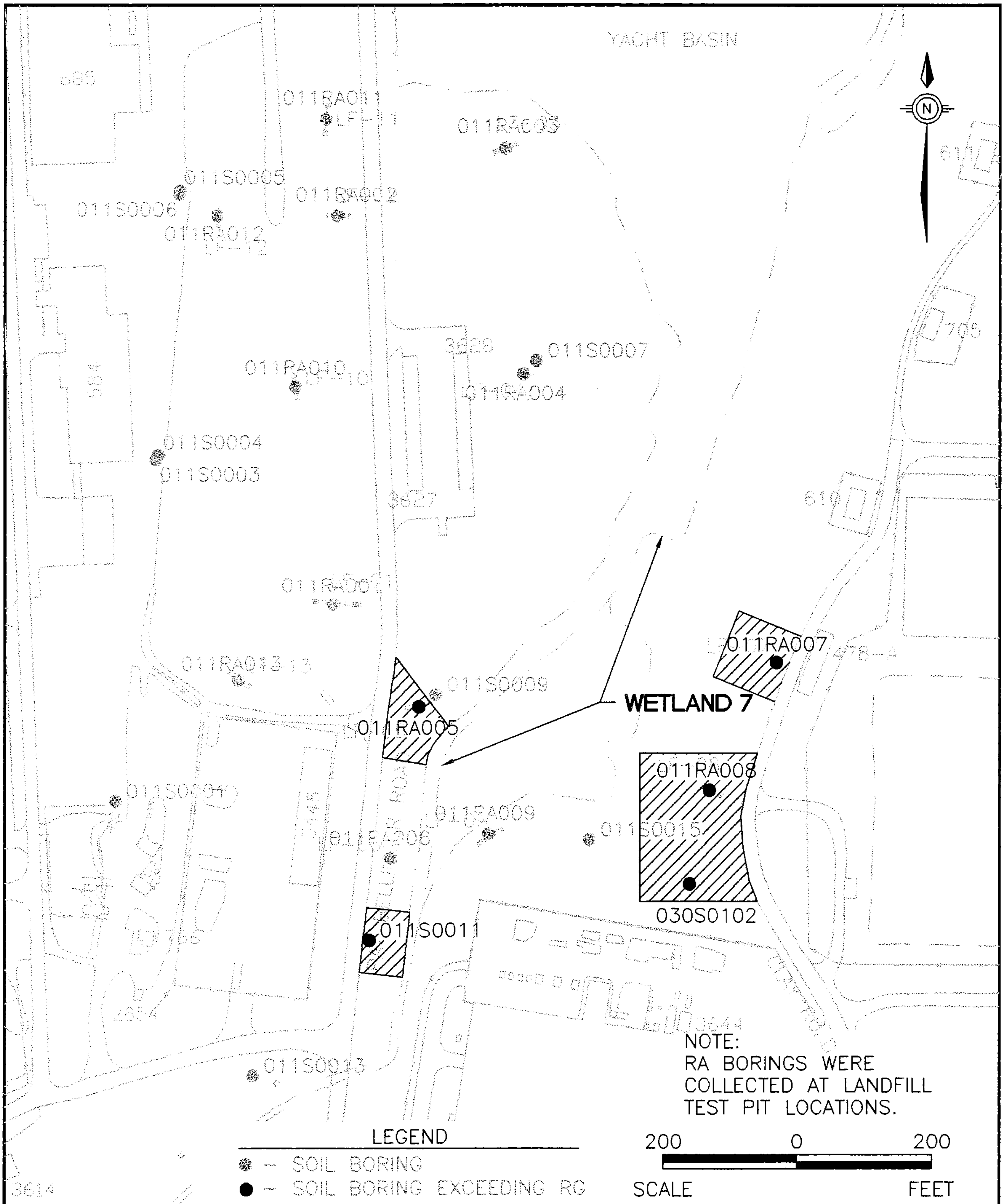
3.3 Site 11 Soil Technologies Screening

Table 3-7 presents various remedial technologies applicable to polynuclear aromatic hydrocarbons (PAHs) and inorganics in soil. This table evaluates each technology's applicability to Site 11, and is used to screen out technologies that are infeasible given site conditions. As discussed in Section 2, technologies have been screened for implementability, effectiveness, and cost.

The technologies retained for use at Site 11 after screening are:

- No Action, as required by the NCP.
- Institutional controls, which will be needed to maintain the industrial-use classification
- Capping
- In situ bioremediation
- Phytoremediation
- Excavation with offsite disposal

Table 3-7 includes screening comments for each technology; the rationale for discarding other technologies is discussed in the following paragraphs.



DRAFT FEASIBILITY STUDY
OPERABLE UNIT 2
NAS PENSACOLA
PENSACOLA, FLORIDA

FIGURE 3–5
SITE 11
SOIL AREAS EXCEEDING RGs

DWG DATE: 04/21/99 | DWG NAME: 0059B011

Table 3-7
Soil Technology Screening — Site 11

Technology	Description	Implementability	Effectiveness	Cost
CONTAINMENT				
Surface Cap	Capping is a containment technology that will limit human contact with soil and reduce infiltration of rainwater through contaminated soil. Capping materials include soil, asphalt, and concrete.	All contamination identified at Site 11 is adjacent to roadways or parking lots. Contaminated areas may be paved easily. Because several points are in or adjacent to Wetlands 7 and 64, remedial actions at Site 11 must comply with floodplain requirements.	Caps eliminate the ingestion/ inhalation/contact pathway, and therefore are effective at reducing risk to human health. With ongoing maintenance, the long-term effectiveness of a cap is high. Capping is an effective means of eliminating risk pathways, but it does not meet any preference for treatment, nor does it reduce contaminant toxicity, mobility, or volume.	Because this cap is intended only to eliminate a risk pathway and not to isolate waste or reduce infiltration, a multi-layer cap is not required. Costs for common capping material, such as soil, asphalt, or concrete, are comparatively low. Maintenance costs are also low.
IN SITU TREATMENT TECHNOLOGIES				
Bioremediation	Naturally occurring microbes are stimulated by amending contaminated soils to enhance biodegradation. Nutrients, oxygen, hydrogen peroxide, and other amendments may enhance biodegradation and contaminant desorption from subsurface materials. Amendments may be added through solution (such as water), or they may be mixed into the soil using tillers or rippers. When mechanical mixing is required, such as with in situ land farming applications, in situ bioremediation effectiveness is limited at depth. Similarly, effectiveness may be limited if deeper zones exhibit preferential pathways and nutrient/ amendment delivery is irregular. Bioremediation may occur in aerobic and anaerobic conditions. In some cases, commercially obtained microbes may be used to supplement native populations.	Bioremediation may be technically implementable at Site 11; contamination is limited to the top 2 feet, and thus may easily be controlled. Because several points are in or adjacent to Wetlands 7 and 64, remedial actions at Site 11 must comply with floodplain requirements.	The primary organic contaminants at Site 11 are PAHs, which are generally biodegradable. Arsenic and chromium contamination is not amenable to biological techniques; soil exhibiting concentrations above RGs will not be affected by in situ biological techniques. Because contamination is limited to the top 2 feet, it may be easy to monitor and control. In addition, the porous nature of the impacted media may facilitate uniform amendment delivery. Degradation of PAHs is typically slower than more amenable compounds, such as benzene, toluene, ethylbenzene, and xylene (BTEX). Although high concentrations of heavy metals, highly chlorinated organics, long-chain hydrocarbons, or inorganic salts are likely to be toxic to microorganisms, these conditions do not exist at Site 11. Because, the remedial goals for several PAH compounds are low, less than 1 milligram per kilogram (mg/kg), it may be difficult to sustain a microbial population at this low concentration. Bioremediation enhances biodegradation, and therefore is considered a destructive technology.	Bioremediation costs are typically variable because the need for amendments is highly site specific. However, in situ bioremediation costs are typically lower than other in situ technologies such as soil vapor extraction (SVE).

Table 3-7
Soil Technology Screening — Site 11

Technology	Description	Implementability	Effectiveness	Cost
Bioventing	Air is either extracted from or injected into unsaturated soil to increase oxygen concentrations and stimulate biological activity. Bioventing is applicable for any contaminant that more readily degrades aerobically than anaerobically. This process is used to deliver amendments to zones deeper than what can be managed by bioremediation practices alone. Flow rates are much lower than soil vapor extraction, minimizing volatilization and release of contaminants to the atmosphere. Where preferential pathways exist in the vadose zone, air flow may not reach all contaminated media.	Bioventing is not technically implementable at Site 11, given that contamination is limited to the 0- to 2-foot interval. In addition, a shallow groundwater table precludes the use of venting techniques. Because several points are in or adjacent to Wetlands 7 and 64, remedial actions at Site 11 must comply with floodplain requirements.	Bioventing is unlikely to be more effective than natural degradation processes at this site, given that surface soil is already highly oxygenated. Bioventing enhances biodegradation, and therefore is considered a destructive technology.	Bioventing is relatively inexpensive, though ongoing use of blowers and ancillary piping will require O&M.

Table 3-7
Soil Technology Screening — Site 11

Technology	Description	Implementability	Effectiveness	Cost
Phytoremediation	Phytoremediation is the use of plants to remove, contain, and/or degrade contaminants. Examples include: plant-enhanced bioremediation, phytoaccumulation, phytodegradation, and phytostabilization. Climatic or hydrologic conditions may restrict the rate of growth of the remediation plants.	Phytoremediation may be technically implementable at Site 11; contamination is limited to the top 2 feet, and thus there is likely a wide variety of plants which may be used to remediate site soil. Implementation of phytoremediation will require identifying a plant or plants amenable to all site compounds (PAHs, arsenic, chromium), and optimizing growing conditions.. Due to time required for remediation, plans for future site use may be impacted by phytoremediation. Because several points are in or adjacent to Wetlands 7 and 64, remedial actions at Site 11 must comply with floodplain requirements.	Phytoremediation is an innovative technology that may be effective at Site 11 given that contamination is limited to the top 2 feet, well within the root zones of some plants. Shallow contamination is easily monitored and controlled. Although high concentrations of hazardous materials can be toxic to plants, contaminant concentrations at Site 11 are not excessive. Phytoremediation may be a destructive remediation technology, depending on the type of plants used. It may also be used as a containment or immobilization strategy, binding contaminants in soil or biomass. However, there is concern that phytoremediation is reversible. Additionally, plants that have died or which are removed from the site may require special management or handling due to concentrated contaminants within the biomass.	Costs for phytoremediation are expected to be low compared with other in situ techniques. Maintenance costs are also expected to be relatively low, consisting of monitoring and watering costs.

Table 3-7
Soil Technology Screening — Site 11

Technology	Description	Implementability	Effectiveness	Cost
In Situ Solidification/ Stabilization	In situ stabilization immobilizes contaminants by mixing site soil with portland cement, lime, or a chemical reagent to reduce the mobility of the contaminant. Large augering equipment is used to mix soils in place with the reagent. This technology will likely leave a solid mass (similar to concrete) onsite.	This technology may not be technically implementable at Site 11 if large debris is present in surface or subsurface soil. Contaminated soil is limited to the 0- to 2-foot interval, which is easily mixed. The stabilized mass may be left in place. Because several points are in or adjacent to Wetlands 7 and 64, remedial actions at Site 11 must comply with floodplain requirements.	Solidification/stabilization can be an effective containment strategy for organic compounds . However, this technology works better for inorganics including radionuclides. Some organic-contaminated soils may delay or inhibit reactions necessary for solidification. Long-term, the stabilized mass can degrade, particularly if subject to repeated abuse. Solidification/stabilization is not a permanent treatment technology and does not remove or destroy contaminants; rather, contaminants are immobilized. Treated media typically must be managed long term (e.g., through institutional controls and monitoring).	Solidification/stabilization costs typically vary given the stabilizing material required (e.g., fly ash, portland cement, etc.). However, these costs are typically low compared with destructive in situ options.
		EX SITU TREATMENT TECHNOLOGIES		
Solid-phase biodegradation. • Biopiles • White rot fungus • Landfarming	Excavated soils are mixed with amendments, nutrients, enzymes, or fillers and placed in aboveground enclosures. Mixing may be required, as in a traditional landfarming application. Conversely, biopiles may be used simply to deliver oxygen uniformly throughout a large pile. Ex situ biological systems may be designed to degrade specific compounds and maintain specified degradation conditions (aerobic vs. anaerobic). Mechanical mixing, such as tilling or turning of windrows, may be required.	Ex situ bioremediation is technically implementable at Site 11. A large amount of space is required for solid phase ex situ bioremediation. Because several points are in or adjacent to Wetlands 7 and 64, remedial actions at Site 11 must comply with floodplain requirements.	Ex situ bioremediation systems may be tailored to the specific contaminant requiring treatment. Biodegradation is typically limited to organic compounds, and heavy metals may be toxic to microorganisms. Remediation half-lives for PAHs may be slower than more degradable compounds, such as BTEX, which may extend the remediation time frame. Arsenic and chromium concentrations will not be reduced through biological activity. Remedial goals for some PAHs are less than 1 mg/kg, and may be inadequate to sustain a microbial population without a supplemental carbon source. Solid phase bioremediation is a permanent , destructive technology. However, there is some risk of incomplete reaction byproducts.	Ex situ solid phase bioremediation is inexpensive compared with other ex situ techniques. However, given the need to design specific nutrient amendments and process control systems, more recalcitrant organics are typically more expensive to treat.

Table 3-7
Soil Technology Screening — Site 11

Technology	Description	Implementability	Effectiveness	Cost
Slurry Phase Biological Treatment	Slurry-phase bioreactors containing co-metabolites and specially adapted microorganisms can be used to treat halogenated VOCs and SVOCs, pesticides, and PCBs. An aqueous slurry is created by combining soil with water and other additives. The slurry is mixed continuously to keep solids suspended and microorganisms in contact with the soil contaminants. Upon completion of the process, the slurry is dewatered and the treated soil is disposed of.	Ex situ bioremediation is technically implementable at Site 11. A large amount of space is required for slurry phase ex situ bioremediation. Because several points are in or adjacent to Wetlands 7 and 64, remedial actions at Site 11 must comply with floodplain requirements.	Slurry-phase bioreactors are used primarily to treat nonhalogenated SVOCs and VOCs in excavated soils or dredged sediments. Ex situ bioremediation systems may be tailored to the specific contaminant requiring treatment. Biodegradation is typically limited to organic compounds, and heavy metals may be toxic to microorganisms. Arsenic and chromium contamination at Site 11 will not be treated by biological remedies. Remediation half-lives for PAHs may be slower than more degradeable compounds, such as BTEX, which may extend the remediation time frame. If supplemental carbon is required to sustain microbes and improve treatment system effectiveness, application rates can be easily controlled in a slurry system. Slurry phase bioremediation is a permanent, destructive technology.	Ex situ slurry phase bioremediation is expensive compared with other biological techniques, due to the controls and materials handling required.

Table 3-7
Soil Technology Screening — Site 11

Technology	Description	Implementability	Effectiveness	Cost
Soil Washing • Chemical Extraction • Acid Extraction • Solvent Extraction • Separation Techniques	Excavated soil is washed with aqueous-based solutions to separate contaminants sorbed onto fine particles from the rest of the soil matrix. The fractions of soil to be treated are processed in a slurry with specific leachant mixtures to ionize target metals. The solvent/waste mixture is then treated further to develop a concentrated leaching solution which may be treated or disposed of offsite. Traditional soil washing options may also include separation techniques which concentrate contaminated solids through physical and chemical means. These processes seek to detach contaminants from their medium (e.g., soil, sand, or other binding material). Gravity separation, magnetic separation, and sieving/physical separation are examples of this technology.	With approximately 4,140 CY of contaminated soil, soil washing may be implementable at Site 11. The system must be designed to remove each contaminant. Soil washing systems will require operational space as well as possible water and sewer connections. Because several points are in or adjacent to Wetlands 7 and 64, remedial actions at Site 11 must comply with floodplain requirements.	Overall, this technology is effective at removing SVOCs and inorganics. It is less effective at treating VOCs. In general, acid extraction techniques are suitable for treating soils contaminated by heavy metals. Solvent extraction has been shown to be effective in treating soils containing primarily organic contaminants, but is generally least effective on very high molecular weight organic and very hydrophilic substances. Soils with higher clay content may reduce extraction efficiency and require longer contact times. High humic content in soil may require pretreatment. It may be difficult to remove organics adsorbed to clay-size particles. Soil washing is a permanent treatment technology which removes contaminants from soil to another medium (e.g., solvent, carbon, etc.). Treatment residuals then may require treatment or disposal. Soil washing solvents may also pose environmental risks.	Soil washing is typically an expensive remediation alternative because of the highly site-specific design requirements and the need to treat and/or dispose of the leaching solvent. With approximately 4,140 CY of contaminated soil, soil washing may be possible at Site 11 assuming treatability studies are favorable and can be cost effectively focused on specific site contaminants.
Chemical/ Physical Oxidation • permanganate flooding • Fenton's reagent • Wet air oxidation • Supercritical water oxidation	Chemical oxidation is a process in which the oxidation state of a contaminant is increased while the oxidation state of the reactant is decreased. The reactant can be another element, including the oxygen molecule, or it may be a chemical species containing oxygen, such as hydrogen peroxide or chlorine dioxide. In the case of physical oxidation technologies, wet air oxidation and supercritical water oxidation both use high pressure and temperature to treat organic contaminants.	With approximately 4,140 CY of contaminated soil, chemical/physical oxidation may be implementable at Site 11. Treatability studies must be performed to determine reagent doses. Iron and manganese in the soil will compete with contaminants for oxygen. Because several points are in or adjacent to Wetlands 7 and 64, remedial actions at Site 11 must comply with floodplain requirements.	This technology is effective in treating media contaminated with halogenated and non-halogenated volatiles and semivolatiles, PCBs, pesticides, cyanides, and volatile and nonvolatile metals. Wet air oxidation can treat hydrocarbons and other organic compounds. Supercritical water oxidation is applicable for PCBs and other stable compounds. Oxidation is a permanent treatment technology in which contaminants are destroyed.	Costs for chemical oxidation processes may be comparable to soil washing costs, given the need to construct and operate ex situ reactors, and the need to control reagents and reactor conditions. Costs may vary widely with the type of oxidation technique implemented.

Table 3-7
Soil Technology Screening — Site 11

Technology	Description	Implementability	Effectiveness	Cost
Ex Situ Solidification/ Stabilization	Contaminants are physically bound or encased within a stabilized mass, or chemical reactions are induced with stabilizing agents. The contaminants are not removed or destroyed, but their mobility is reduced. Examples of S/S technologies include: bituminization, emulsified asphalt, modified sulfur cement, polyethylene extrusion, pozzolan/portland cement, radioactive waste solidification, sludge stabilization, and soluble phosphates.	Ex situ stabilization/ solidification is the best-demonstrated technology for multiple compounds. It is technically implementable, and often required to render contaminants non-hazardous before offsite disposal. Site contaminants are non-hazardous PAHs, arsenic, and chromium, and it is unlikely that it will be necessary to render these concentrations lower to meet treatment standards. Because several points are in or adjacent to Wetlands 7 and 64, remedial actions at Site 11 must comply with floodplain requirements.	This technology works well for inorganics including radionuclides. Although organic- contaminated soils may be treated with solidification/stabilization, some organics can delay or inhibit reactions necessary for solidification. Solidification/ stabilization is not a permanent treatment technology and does not remove or destroy contaminants; rather, contaminants are immobilized. Treated media typically must be managed appropriately, i.e., landfilled or contained onsite. Where used as asphalt or similar covers, degradation due to normal asphalt weathering should be considered.	Solidification/stabilization costs typically vary given the stabilizing material required (e.g., fly ash, portland cement, etc.). However, ex situ stabilization/ solidification is inexpensive compared with other ex situ technologies.

Table 3-7
Soil Technology Screening — Site 11

Technology	Description	Implementability	Effectiveness	Cost
Incineration/ Pyrolysis	Incineration burns contaminated sediment at high temperatures (1,600° — 2,200°F) to volatilize and combust organic contaminants. A combustion gas treatment system must be included with the incinerator. The circulating bed combustion, fluidized bed reactor, infrared combustion, and rotary kiln are several types of incinerators. Pyrolysis chemically changes contaminated sediment by heating it in the absence of air. Pyrolysis can be achieved by limiting oxygen to rotary kilns and fluidized bed reactors. Molten salt destruction is another example of pyrolysis.	Incineration is technically implementable at Site 11. However, the lead agency will likely be reluctant to construct an incineration unit for a small-volume, short-term project. Administrative implementability will be limited by the need for submitting documentation and testing the unit's compliance with ARARs. Administrative implementability is also limited given current and future site use. Any actions should be coordinated with radioactive soil remediation plans being developed by RASO. Highly abrasive feed can damage the processor unit. The technology requires drying the soil to achieve less than 1% moisture content. Because several points are in or adjacent to Wetlands 7 and 64, remedial actions at Site 11 must comply with floodplain requirements.	Incineration may be effective in treating organic-contaminated soil, but not for soil with metals as the primary contaminants. The target contaminant groups for pyrolysis are SVOCs and pesticides. Pyrolysis is not effective in either destroying or physically separating inorganics from the contaminated medium. Volatile metals may be removed by the higher temperatures, but are not destroyed. Incineration is a permanent treatment technology; COCs are destroyed during treatment.	Incineration/ pyrolysis are typically very expensive remedial options compared with other ex situ remediation. The low contaminant concentrations at Site 11 can be treated using other technologies, rendering this technology cost-prohibitive.

Table 3-7
Soil Technology Screening — Site 11

Technology	Description	Implementability	Effectiveness	Cost
Thermal Desorption	Soil is generally heated between 200° and 1,000°F to separate VOCs, water, and some SVOCs from the solids into a gas stream. The organics in the gas stream must be treated or captured. Thermal desorption may be used at high or low temperatures depending on the volatility of the contaminants.	Thermal desorption is technically implementable at Site 11. Some thermal desorbers may be regulated as incinerators, depending on construction. Testing and optimization would be required. Highly abrasive feed can damage the processor unit. Although clay and silty soils and soil with high humic content increase reaction time due to binding of contaminants, this problem would not be anticipated for Site 11. Because several points are in or adjacent to Wetlands 7 and 64, remedial actions at Site 11 must comply with floodplain requirements.	Thermal desorption units are effective at removing primarily organic contaminants. Residence time and temperature inside the unit can be varied to volatilize recalcitrant organics. Inorganic contaminants or metals that are not particularly volatile will not be effectively removed by thermal desorption. Arsenic and chromium contaminated soil will not be addressed by this technology. Vapor phase organics must be concentrated and treated or otherwise disposed of. Thermal desorption is a permanent treatment technology which will eliminate risk by removing COCs from site soil.	Although less expensive than other ex situ thermal treatment methods, thermal desorption is still comparatively expensive. Costs increase with the degree of materials handling, pre-and post- treatment, and off-gas controls required. With approximately 4,140 CY of contaminated soil thermal desorption may be possible at Site 11 assuming treatability studies are favorable and can manage specific site organic contaminants cost effectively.

Table 3-7
Soil Technology Screening — Site 11

Technology	Description	Implementability	Effectiveness	Cost
Excavation and Offsite Disposal	Contaminated soil is excavated and disposed of offsite at a licensed waste disposal facility.	Excavation with offsite disposal is both technically and administratively implementable at Site 11. Contaminated media can be removed and disposed offsite. The excavated areas can then be backfilled with clean fill with minimal impact to operations at adjacent buildings. Testing will be required before the soil is disposed of; toxicity characteristic leachate procedure (TCLP) results may impact disposal options. Transporting soil through populated areas may affect community acceptance. Because several points are in or adjacent to Wetlands 7 and 64, remedial actions at Site 11 must comply with floodplain requirements.	Excavation with offsite disposal is expected to be an effective remediation option. It is effective for all contaminants because the risk pathway is eliminated. This is a permanent remedial technology.	Costs for excavation and offsite disposal vary, depending on whether waste is classified as hazardous. However, compared with other options (including treatment or disposal at an incineration facility), landfilling is relatively less expensive.

In situ solidification/stabilization was discarded from consideration because the site is a former landfill. Shallow mixing of surface soil might be compromised by the presence of concrete, asphalt, or other debris in the landfill. Ex situ techniques were also discarded because solidification/stabilization is primarily used to minimize leaching and contaminant mobility, which is not a problem for PAHs and pesticides. While solidification/stabilization is applicable to arsenic- and chromium-contaminated soil, contaminant concentrations at Site 11 are not high enough to threaten the underlying aquifer. Both inorganics were identified only because they exceeded human health standards for industrial site workers.

Ex situ reactor-based treatment, such as solid and slurry phase biodegradation, soil washing, and chemical oxidation, are all high-cost technologies which require significant capital for system construction. Effectiveness of each of these technologies is highly variable, and depends on site specifics such as soil parameters and chemicals constituents. Effectiveness is also questionable as contaminant concentrations approach RGs; remediation of PAHs may not be sustainable at concentrations of 1 part per million or less. These technologies were discarded in favor of in situ approaches with similar uncertainties.

Thermal treatments, such as incineration, pyrolysis, and thermal desorption, although effective for organic compounds, were discarded because of their high costs and implementation obstacles associated with meeting ARARs. If thermal treatment is identified at another site as a viable option, consolidation might be considered. However, contamination across OU 2 is significantly low enough that other treatment options will likely meet the statutory preference for treatment.

3.4 Site 11 Assembly of Alternatives

The following alternatives have been retained for Site 11 soil.

- Alternative 1: No Action
- Alternative 2: Institutional controls
- Alternative 3: Soil cover
- Alternative 4: Plant-enhanced bioremediation
- Alternative 5: Excavation with Offsite Disposal

3.4.1 Alternative 1: No Action

Under this alternative, no changes would be made to existing site operations or exposure scenarios. While the current and projected land use for this site is expected to remain industrial, there are no institutional controls to guarantee the exposure pathway would remain industrial. Without controls, a residential scenario must be assumed in which all existing pavement and buildings are removed.

Implementability

The no-action alternative could be easily implemented. The Navy would be required to perform a 5-year review to assess adequacy of the alternative.

Effectiveness

The no-action alternative is not effective at protecting human health, as contaminants above residential and industrial SCTLs are left onsite. As discussed in the BRA, Site 11 soil presents a combined soil ingestion/contact pathway risk of 2.7E-05 to potential future site residents; this risk is within the allowable range cited in the NCP (1E-06 to 1E-04), but exceeds the FDEP threshold criteria of 1E-06. Residential exposures, however, are unlikely given that:

- Site 11 is an old landfill, typically regarded as undesirable for residential construction.
- Site 11 is in and/or adjacent to Wetlands 64 and 7; construction activities in these areas are unlikely.

Cost

Table 3-8 presents the costs associated with the no-action alternative.

Table 3-8
Alternative 1 — Costs for No Action

Action	Quantity	Cost per Unit	Total Cost
Five Year Review	LS	$10,000	$10,000
Present value subtotal at 6% discount over 30 years			$24,400
Total Cost			**$24,400 ***

Notes:
LS = Lump sum
* Cost based on review once every five years for 30 years.

3.4.2 Alternative 2: Institutional Controls

No remedial actions will be implemented under this alternative. Institutional controls, such as land use control agreements (LUCAs) would be implemented to limit access and property use to industrial/commercial, thereby limiting unacceptable exposure to contamination.

This alternative does not require any changes to existing activities, since current land use at Site 11 is industrial. However, controls would be required to minimize exposures which could include maintenance activities in impacted areas. Notification of the Base Environmental office would be required to ensure proper instruction before invasive activities begin.

Implementability

Implementation of this alternative does not require any innovative technologies or construction activities; ongoing operations would not be interrupted. This alternative would require the Navy to control site access and keep its use industrial/commercial. Site access can be controlled through the LUCAs and/or warnings against excavation. The site would be inspected annually to ensure compliance with the LUCA. If the property was no longer under direct Navy control, development of a deed restriction would be necessary. The Navy has base planners and attorneys on staff with experience to develop and implement proper institutional controls for Site 11. The possibility of transferring Site 11 to civilian control is highly unlikely in the near future; therefore, proper controls can be implemented through planning.

The NCP requires any alternative which leaves contamination onsite to be reevaluated every 5 years to ensure its adequacy. Therefore, the institutional controls alternative would require the Navy to establish a monitoring program.

Effectiveness

Institutional controls at Site 11 would limit unacceptable exposure to surface soil contamination. Under current site conditions, surface soil exceeds ISCTLs at four sample locations where surface soil is exposed. This alternative would not provide any additional effectiveness for the current use scenario, but would provide long-term effectiveness by restricting future use and access. However, workers would be exposed only during activities in which they contact surface soil. No risks are posed during implementation of institutional controls.

This alternative also ensures that intrusive activities are not permitted in or near other impacted areas where concentrations exceed ISCTLs.

This alternative does not provide more protection to site workers than the current scenario, but it does eliminate the future resident exposure pathway by excluding the property from residential use. Likely exposures will be less than the worst case assumed in SCTL development (see *Technical Report: Development of Soil Cleanup Target Levels*, ERC Hearing Draft, May 1999). Moreover, it is unlikely that impacted areas will be approved for industrial use because:

- Site 11 is an old landfill, typically regarded as undesirable for industrial applications.
- Site 11 is in and/or adjacent to Wetlands 64 and 7; construction activities within these areas is unlikely.

If construction and industrial applications were to be implemented in contaminated areas, significant site development would be required; land-use restrictions could include a provision that development be accompanied by removal actions.

As demonstrated in the HHBRA, Site 11 exhibits a combined ingestion/contact pathway risk of 5.1E-06 for future site workers. This risk is on the low end of the NCP's allowable risk range (1E-06 to 1E-04); it exceeds FDEP's risk threshold of 1E-06.

Cost

The total present-worth cost of the institutional controls alternative is estimated at $74,400.

As shown in Table 3-9, the Navy assumes implementation of institutional controls will cost approximately $50,000, which is the estimated cost for completing the necessary documentation and annual review of site use. In addition, a 5-year reevaluation of site conditions will be required for 30 years, as per the NCP. The estimated cost for each reevaluation is $10,000 per event; assuming a 6% discount rate over 30 years, the present worth of reevaluation requirements is approximately $24,400.

Table 3-9
Alternative 2 — Costs for Institutional Controls

Action	Quantity	Cost per Unit	Total Cost
Five Year Review	LS	$10,000	$10,000
Present value subtotal at 6% discount over 30 years			$24,400*
Institutional Controls (LUCA and Signs)	LS	$50,000	$50,000
Total Cost			**$74,400**

Notes:
LS = lump sum.
* Cost based on review once every five years for 30 years.

3.4.3 Alternative 3: Soil Cover

Installing a soil cover over contaminated areas would reduce the risk of site workers contacting exposed contaminated soil, thus eliminating exposure pathways. Institutional controls would also be incorporated to restrict future access to contaminated soil. The proposed cover locations are shown in Figure 3-6.

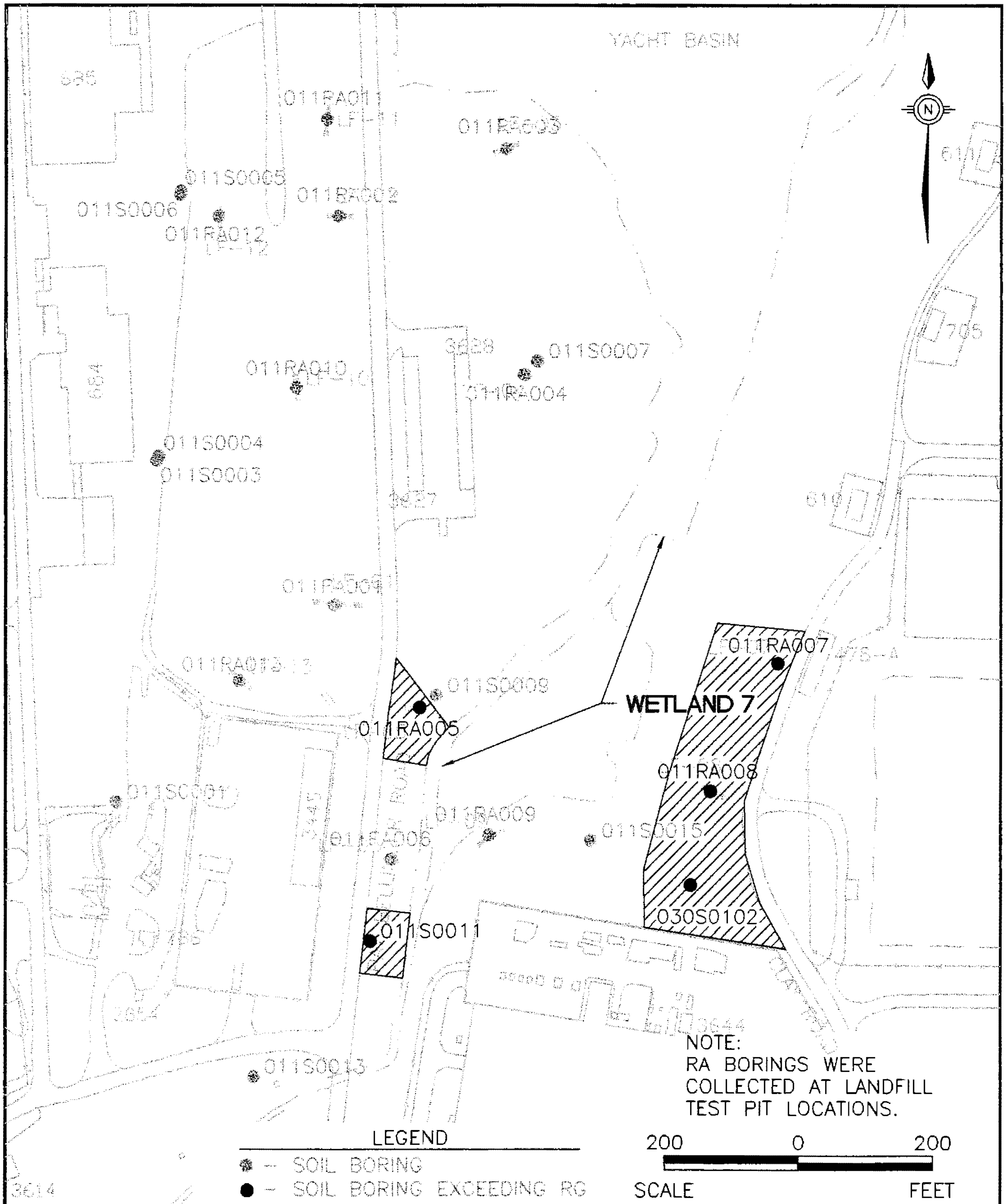
Remedial activities for the soil cover would consist of:

- Implementing institutional controls (LUCA)
- Confirmatory sampling
- Site preparation
- Cover placement

Cover construction would consist of 24 inches of soil placed over contaminated areas. The area would be sloped to manage storm water runoff and prevent erosion and the surface would be vegetated. Confirmation sampling would help delineate the extent of soil in which contaminant concentrations exceed the RG to ensure that all contaminated soil is covered. Soil covers were selected over other options (asphalt, concrete) because impacted areas are adjacent to wetlands and woods, and placement of a soil cover would be less destructive to these ecosystems.

Implementability

Cover construction with institutional controls is technically feasible at Site 11. Land use restrictions may be used to implement institutional controls. The Site 11 areas that would be covered are shown in Figure 3-6, Proposed Cover Locations. The total area to be covered is presented in Table 3-10. Actual areas to be covered would be determined in the field following confirmation sampling. Regular maintenance would be required to ensure the covers do not degrade or erode, and additional soil may be required if covers deteriorate significantly.



DRAFT FEASIBILITY STUDY
OPERABLE UNIT 2
NAS PENSACOLA
PENSACOLA, FLORIDA

FIGURE 3–6
SITE 11
PROPOSED COVER LOCATIONS

DWG DATE: 04/21/99 | DWG NAME: 0059B012

Table 3-10
Areas to be Covered

Location	Estimated Cover Dimensions	Surface Area (ft^2)
011S0011	irregular	7,875
011SRA005	60 ft by 100 ft	6,000
011SRA07, 011SRA08, 030S0102	irregular	65,000
Total Paved Area		**78,875**

Note:
ft^2 = square feet

Effectiveness

Covers provide reliable protection against dermal contact with and ingestion of contaminated soil. They isolate contaminants exceeding risk and guidance concentrations in environmental media, but are not designed to manage solid or hazardous waste. Confirmation sampling will ensure that the entire area exceeding RGs is covered. Once the cover is in place, institutional controls would help ensure continued cover effectiveness and regular maintenance would be required.

Cost

Table 3-11 presents the capital costs associated with installation of a soil cover and institutional controls.

Table 3-11
Alternative 3 — Costs for Soil Cover

Action	Quantity	Cost per Unit	Total Cost
Capital Costs for Soil Cover			
Mobilization/Demobilization	LS	$500/location	$1,500
Grading/site preparation	8,764 yd^2	$1.50/$yd^2$	$13,150
Soil cover/vegetation	5,872 CY	$15/CY	$88,080
Engineering/Oversight	LS[1]	20% cost	$20,280
Contingency/Miscellaneous	LS[1]	25% cost	$25,350
Subtotal			**$148,360**

Table 3-11
Alternative 3 — Costs for Soil Cover

Action	Quantity	Cost per Unit	Total Cost
Operation and Maintenance Cost			
Maintain cover (30 years)	6,780 yd^2	$2/$yd^2$	$13,560
Inspection	LS[1]	$500	$500
Subtotal			$14,060
Present value at 6% discount over 30 years			$193,540
Confirmation Sampling	12 samples (plus 2 QA/QC samples)	$500/sample	$7,000*
Institutional Controls (LUCA and signs)		LS	$50,000
Subtotal			$57,000
Remedial Contractor Cost			$100,000
Total Cost			$498,900

Notes:
LS = Lump sum
yd^2 = square yard
* Assumes one sample will be collected along each edge of the contaminated area. Samples will be analyzed for SVOCs and inorganics.

3.4.4 Alternative 4: Plant-Assisted Bioremediation

Plant-assisted bioremediation could be implemented at Site 11 because impacted areas are away from day-to-day activities, and will not interfere with parking or access to adjacent properties.

Impacted areas would be remediated using existing microbial populations and supplementing them with nutrients. Moisture and other soil properties would be optimized to enhance biological activity. If bench- and pilot-scale work indicated that bioremediation alone was insufficient to achieve RGs, plant-enhanced bioremediation (also known as phyto-stimulation) would be implemented to augment microbial degradation. Plant-assisted bioremediation uses plants to stimulate microbial activity within the root zone: plants provide supplemental carbon and oxygen within the contaminated zone, thus improving degradation kinetics. Phytoremediation mechanisms can remove contaminants directly through mineralization (also called transformation) to carbon dioxide and water, or through uptake, in which contaminants are concentrated in vegetation or root-mass. Other species can stabilize contaminants, generally metals, through changes in oxidation/reduction conditions and precipitation, thus reducing toxicity and/or mobility.

Remedial activities would include:

- Implement institutional controls (LUCA)

- Bench-scale laboratory testing to determine soil properties (optimal moisture content, pH, etc.), amendment requirements (oxygen, nitrogen, phosphorus), and degradation rates.

- Research to determine optimal plants for PAH remediation in northwest Florida.

- Field-scale testing to evaluate in situ degradation rates with and without phytostimulators (supplemental plants).

- Construction of treatment areas, including:

    - Berms and access controls
    - Irrigation systems
    - Nutrient metering tanks and pumps

- Ongoing monitoring and tillage (if required)

Implementability

Bioremediation of PAH-contaminated soil is technically implementable at Site 11. Pilot-scale testing would necessary prior to full-scale treatment. Institutional controls would be required to restrict access to impacted areas during remediation, and to control future use. The shallow contamination and porous soil are amenable to in situ biological technologies. If pilot-scale studies indicate that nutrient amendments alone are insufficient to reduce contaminant concentrations to RGs, bioremediation may be supplemented with phytoremediation. Phytoremediation is an innovative technology noted to be effective at PAH sites (Pradhan, 1998). Additional research and pilot testing will be required to identify plants appropriate to PAH degradation in northwest Florida. Tillage, if required, may be hampered by the presence of debris. It is important to note that detection limits seen in current analytical techniques (such as Contract Laboratory Program [CLP] SVOCs or SW-846 Method 8270) are only slightly lower than site-specific RGs; analytical interferences, which are common for soil analyses, may elevate detection limits above site RGs, making it difficult to assess remediation progress when soil concentrations drop below 1 mg/kg.

Effectiveness

Bioremediation alternatives are expected to be effective in reducing contaminant concentrations; effectiveness may be limited, however, as concentrations approach RGs. It is possible that organic contaminant concentrations in the low part-per-million range are insufficient to support microbial populations. It may be possible to enhance degradation through phytoremediation, although, it is unclear if phytoremediation can achieve significant reductions when bioavailability is low (i.e., biomass may be the limiting factor). Plant-assisted bioremediation, in addition to supplementing microbial activity, can remove contaminants directly from soil — either through uptake into vegetation or transformation (mineralization) within the root system. Remediation time frames for both bioremediation and phytoremediation depend on site-specific degradation kinetics. Bioremediation alone will not address arsenic and chromium concentrations; however, plant-assisted bioremediation may be tailored to maximize plant uptake.

Cost

Bioremediation costs typically range from $50 to $150 per cubic yard, excluding bench- and pilot-scale testing. Phytoremediation is a new technology, and costs for full-scale projects are not available. However, it is considered a low-cost adjunct to engineered biodegradation, with literature estimates of total remediation costs (including grading, planting, monitoring, etc.) between $60,000 and $100,000 per acre (less than $2.50/ft^2). Because of the uncertainties associated with an innovative technology, $2.50/ft^2 has been used to estimate costs, but actual costs may be lower. If transfer to vegetation is the primary removal mechanism and plants will require harvesting and disposal, costs will likely increase. Table 3-12 presents theoretical costs for a bioremediation system at Site 11, assuming unit costs and basic construction.

Table 3-12
Alternative 4 — Costs for Plant Assisted Bioremediation

Action	Quantity	Cost per Unit	Total Cost
Capital Costs for Plant-Assisted Bioremediation			
Mobilization/Demobilization	LS	$500/location	$1,500
Grading/site preparation	8,764 yd^2	$1.50/yd^2	$13,150
Bioremediation	5,872 CY	$50 to $150/CY	$293,600 to $880,800
Phytoremediation	78,876 ft^2	$2.50/ft^2	$197,190
Engineering/Oversight	LS	20% cost	$218,530
Contingency/Miscellaneous	LS	25% cost	$273,160
Subtotal			$997,130 to $1,584,330
Operation and Maintenance Cost			
Maintenance (30 years)	LS	$5,000	$5,000
Monitoring	16 samples/year (plus 2 QA/QC)	$500/sample	$9,000 *
Inspection	LS	$500	$500
Subtotal			$14,500

Table 3-12
Alternative 4 — Costs for Plant Assisted Bioremediation

Action	Quantity	Cost per Unit	Total Cost
Present value at 6% discount over 30 years			$199,590
Institutional Controls (LUCA and signs)		LS	$50,000
Remedial Contractor Cost			$100,000
Total Cost			$1,346,720 to $1,933,920

Notes:
LS = Lump sum
* Assumes four samples will be collected in the contaminated area. Samples will be analyzed for SVOCs and inorganics.

3.4.5 Alternative 5: Excavation and Offsite Disposal

This alternative involves excavating surface soil in which contaminants exceed compound-specific RGs and disposing of it offsite. Including Site 30 soil, approximately 4,140 CY of surface soil would be removed to eliminate threats to current or future industrial site workers through dermal contact and ingestion exposure pathways. Since soil removal is based on meeting ISCTLs, institutional controls (the LUCA) will be used to ensure that future use remains industrial. Proposed removal areas are shown in Figure 3-5.

Because contaminant concentrations are relatively low (1 to 10 part-per-million range), Site 11 soil is not expected to be considered hazardous waste. Remedial activities would consist of:

- Implement institutional controls (LUCA)
- Excavation
- Confirmatory sampling
- Backfill
- Transport excavated material offsite
- Landfill at a Subtitle D facility

Confirmation samples would be collected from surface soil surrounding the excavation to ensure complete removal of soil in which contaminant concentrations exceed RGs.

After the contaminated soil is removed, clean backfill would be placed in the excavated areas and graded. Toxicity Characteristic Leaching Procedure (TCLP) analysis would be conducted to determine if the excavated soil exhibits toxicity characteristics.

Implementability

This alternative is both technically and administratively feasible at Site 11. Excavation is performed frequently, and is a reliable method to remove contaminated soil within given boundaries. No technology-specific regulations apply to excavation and offsite disposal (i.e., landfilling) alternatives. Except for implementing land use restrictions, no long-term maintenance or monitoring would be required once soil in which contaminant concentrations exceed RGs has been removed. Based on groundwater elevation data presented in the RI report, groundwater is not expected to pose a problem during excavation. Excavation activities will require engineering controls to ensure that impacts to adjacent wetlands and waterbodies are minimized.

Administrative considerations would include:

- Transportation and disposal of contaminated soil must adhere to U.S. Department of Transportation (USDOT) regulations and requirements.

- Scheduling would be required to reduce costs for roll-off boxes and downtime while transporting the soil from Site 11 to the disposal facility.

- Daily operations at the surrounding activities will likely be interrupted on a short-term basis by access problems during the removal process.

No capacity limitations are expected at the landfill, given low projected soil volumes.

Effectiveness

Excavation with offsite disposal would protect the environment at Site 11 by reducing the amount of soil in which contaminant concentrations exceed RGs.

Short-term inhalation, ingestion, and contact risks to site workers (excavation crew) would temporarily increase during excavation, but should last only until remedial actions are complete. Onsite actions will require health and safety practices consistent with PAH contamination and dust generation. These risks will be reduced through proper use of personal protective equipment (PPE) and engineering controls. Because no residential areas are adjacent to Site 11, there are no short-term risks to the surrounding community. No onsite long-term risks are associated with this alternative because exposed soil in which contaminants exceed the FDEP ISCTL would be removed.

Cost

Table 3-13 presents the capital costs associated with excavation and offsite disposal at a Subtitle D facility.

Table 3-13
Alternative 5 — Costs for Excavation with Offsite Disposal

Action	Quantity	Cost per Unit	Total Cost
Excavation	4,140CY	\$20/CY	\$82,800
Confirmation Sampling	20 samples (plus 3 QA/QC samples)	\$750/sample	\$17,250 [a]
Backfill	5,380 CY	\$15/CY	\$80,700 [b]
Subtotal			\$180,750
Subtitle D Disposal Facility			
Transportation	269 trucks (assuming 20 yd^3 each) hauling 30 miles	\$3.50/loaded mile	\$28,250 [b]
Soil Disposal	6,210 tons	\$36/ton	\$223,560 [c]
Engineering/Oversight	LS	20% cost	\$50,360
Contingency/Miscellaneous	LS	25% cost	\$62,950
Subtotal			\$365,120

Table 3-13
Alternative 5 — Costs for Excavation with Offsite Disposal

Action	Quantity	Cost per Unit	Total Cost
Institutional Controls (LUCA and signs)			$50,000
Remedial Contractor Cost			$100,000
Total			$695,870

Notes:
LS = Lump sum
a = Four samples will be collected around each contaminated boring. Samples will be analyzed for SVOCs, pesticides/PCBs, and inorganics.
b = Assumes 30% fluff after excavation.
c = Assumes 1.5 tons per cubic yard.

3.5 Site 11 Detailed Analysis of Alternatives

The following alternatives have been retained for Site 11 soil:

- Alternative 1: No Action
- Alternative 2: Institutional Controls
- Alternative 3: Soil Cover
- Alternative 4: Plant-Enhanced Bioremediation
- Alternative 5: Excavation and Offsite Disposal

Each alternative is evaluated according to the nine criteria discussed in Section 2, which have been divided into three categories — threshold, balancing, and modifying.

3.5.1 Alternative 1: No Action

The no-action alternative for Site 11 involves no active remedial effort. No actions will be taken to contain, remove, or treat soil contamination above RGs. Soil will remain in place. No engineering or institutional controls will be implemented. The no-action alternative provides a baseline against which other alternatives can be compared.

No Action: Threshold Criteria

Overall Protection of Human Health and the Environment: The no-action alternative provides no additional protection of human health and the environment. This alternative assumes that future use will be residential. Site 11 soil exceeds RSCTLs at 10 locations; location 030S0102 also exceeds. These exceedances would remain onsite, unmitigated. As calculated in the BRA, site soil represents a risk of 2.7E-05 under an uncontrolled use (i.e., residential) scenario.

Compliance with ARARs: Alternative 1 does not comply with the RGs developed for Site 11; moreover, contaminants will pose risk under an uncontrolled future use scenario. Florida Proposed Rule 62-777 is a potential ARAR for OU 2. No location- or action-specific ARARs are triggered by the no-action alternative.

No Action: Balancing Criteria

The primary balancing criteria are the technical criteria on which the detailed analysis is based.

Long-term Effectiveness and Permanence: Long-term effectiveness of Alternative 1 is minimal. Soil volumes and concentrations would remain unchanged. In addition, this alternative does not reduce the magnitude of residual risk, and lacks treatment actions that would provide permanence.

Any controls currently in place at the site — military security and limited access to/use of the site — would remain. If use were unrestricted, no controls would be in place to protect potential receptor groups (i.e., residents).

Reduction of Toxicity, Mobility, or Volume Through Treatment: This alternative would not reduce soil contaminant mobility, toxicity, or volume. Contaminants would remain untreated and in place.

Short-Term Effectiveness: Short-term effectiveness assesses an alternative's effect on human health and the environment while it is being implemented. There are no such effects from the no-action alternative.

Implementability: The no-action alternative is technically feasible and easily implemented. No construction, operation, or reliability issues are associated with this alternative. Current access controls — including military security and limited personnel access to the site — have historically been reliable. No administrative coordination, offsite services, materials, specialists, or innovative technologies are required. There are no implementation risks associated with Alternative 1.

Cost: Costs include a site review and report preparation every five years for 30 years. Each review and report are estimated to cost \$10,000, with a present-worth of \$24,400 for the 30-year period.

No Action: Modifying Criteria

The modifying criteria are assessed formally after the public-comment period. However, the criteria are factored into identifying the preferred alternatives, as far as they are known.

State/Support Agency Acceptance: FDEP and the USEPA will have the opportunity to review and comment on this FS.

Community Acceptance: These criteria are generally not completed until after public comments on the RI/FS report and the proposed plan are received.

3.5.2 Alternative 2: Institutional Controls

The institutional controls alternative for Site 11 involves no active remedial effort. No actions will be taken to contain, remove, or treat soil contamination above RGs. Soil would remain in place and institutional controls would be incorporated into the LUCA to ensure Site 11 remains an industrial use area.

Institutional Controls: Threshold Criteria

Overall Protection of Human Health and the Environment: The institutional controls alternative provides additional protection of human health and the environment by reducing the potential for uncontrolled site access. By restricting use to industrial/commercial, future risks from residential ingestion of or contact with soil are eliminated. However, soil contamination at Site 11 exceeds industrial RGs and poses a threat under a future worker scenario. The BRA calculates an industrial site worker risk of 5.1E-6.

Compliance with ARARs: Alternative 2 does not comply with the RGs established for Site 11; Florida Proposed Rule 62-777 is a potential ARAR. No location- or action-specific ARARs are triggered by the institutional controls alternative. Contaminated soil would remain above the RGs.

Institutional Controls: Balancing Criteria

The primary balancing criteria are the technical criteria on which the detailed analysis is based.

Long-Term Effectiveness and Permanence: The long-term effectiveness of institutional controls is limited to the ability to control access to contaminated soil. Soil volumes and concentrations would remain unchanged, and there area no treatment actions that would provide permanence.

Reduction of Toxicity, Mobility, or Volume Through Treatment: The institutional controls alternative would not reduce the mobility, toxicity, or volume of soil contaminants. Contaminants would remain untreated and in place onsite.

Short-Term Effectiveness: Short-term effectiveness assesses an alternative's effect on human health and the environment while it is being implemented. There are no short-term effects resulting from the institutional controls alternative.

Implementability: The institutional controls alternative is technically feasible and easily implemented. No construction issues are associated with this alternative. Current access controls — including military security and limited personnel access to the site — have historically been reliable and will be supplemented through land use restrictions. Administrative coordination is required to implement institutional controls, but no offsite services, materials, specialists, or innovative technologies would be required. There are no implementation risks with Alternative 2.

Cost: Costs include soil monitoring and report preparation every five years for 30 years, plus the cost of establishing the institutional controls. Each sampling and reporting event is estimated to cost $10,000, with a present worth of $24,400 for the 30-year period. Providing the necessary institutional controls is estimated to be a one-time cost of $50,000, for a total cost of $74,400.

Institutional Controls: Modifying Criteria

The modifying criteria are assessed formally after the public-comment period. However, the criteria are factored into identifying the preferred alternatives, as far as they are known.

State/Support Agency Acceptance: FDEP and the USEPA will have the opportunity to review and comment on this FS.

Community Acceptance: These criteria are generally not completed until after public comments on the RI/FS report and the proposed plan are received.

3.5.3 Alternative 3: Soil Cover

This alternative uses a physical barrier to cover the five locations where contaminants exceed RGs. In conjunction with the cover alternative, land use will be restricted to industrial to minimize uncontrolled exposure and prevent cover disturbance.

Soil Cover: Threshold Criteria

Overall Protection of Human Health and the Environment: The soil cover would eliminate the threat of dermal and ingestive contact for current and future site workers. Contaminated soil would be left onsite indefinitely and the cover maintained to ensure adequate protection.

This alternative would protect human health and the environment by physically eliminating receptor pathways and controlling access through land use restrictions. Cover construction and maintenance would be easily implemented, and current site controls (site security, access control, and fencing) and the LUCA would be adequate to ensure minimal disturbance. Short-term risks during implementation from inhalation and dermal contact would be minimal, and could be controlled using common engineering techniques and use of PPE.

Compliance with ARARs: The soil cover with associated institutional controls would comply with RGs for future industrial workers. The potential for contact with soil in which contaminants exceed ISCTLs is eliminated by removing the primary pathways.

The cover would isolate or eliminate contaminants exceeding RGs in environmental media, but not manage solid or hazardous waste. Site grading would need to comply with federal, state, and local air emissions and storm water control regulations. Remedial actions at Site 11 may trigger the following ARARs:

- Floodplain requirements as outlined in the *National Environmental Policy Act* (40 CFR Part 6, Appendix A), *Fish and Wildlife Coordination Act* (40 CFR 6.302).

- Storm water discharge requirements as outlined in the *Clean Water Act* (40 CFR 122, 125, 129, 136) and the *Florida Storm Water Discharge Regulations* (FAC 62-25).

Soil Cover: Balancing Criteria

Long-Term Effectiveness and Permanence: A soil cover would effectively reduce site worker dermal or ingestive contact with contaminated soil, and would require observation and maintenance. Soil covers are generally reliable containment controls, but if it failed, repairs could be made to re-establish the cover's integrity.

This alternative eliminates residual risk to site workers by managing Site 11 as an industrial site and restricting land use. The use of these covered areas would be controlled institutionally.

Reduction of Toxicity, Mobility, or Volume Through Treatment: Constructing a soil cover at Site 11 would not remove, treat, or remediate the contaminated soil; it provides containment only. The soil cover is considered reversible because contaminants exceeding RGs under the cover would remain onsite; if the cover fails because of poor maintenance, contaminants may be exposed. This alternative would not reduce toxicity, mobility, or volume through treatment, nor would it satisfy the statutory preference for treatment.

Short-Term Effectiveness: Adverse impacts to the surrounding environment are not anticipated during cover construction; engineering controls would be applied to manage storm water runoff and siltation. Once design plans are approved, actual cover construction would be expected to take less than one month. During construction, workers would be at risk for dermal or ingestive contact with soil contaminants; however, this risk would be reduced by proper site work practices and use of PPE.

Implementability: A soil cover with institutional controls and limited excavation is technically and administratively feasible. This alternative could be readily applied at the site, because the proposed areas to be covered are easily accessible. Current access controls have been reliable and will be supplemented through the LUCA, and thus implementing this alternative would merely involve placement of the cover and implementation of the LUCA. Future monitoring and maintenance would involve periodic visual cover inspections and repairing any damage or degradation. Repairs are easily implemented, and soil covering would not require any extraordinary services or materials.

Cost: Costs for this alternative are detailed in Section 3.4.3. The total cost for Alternative 3 including the cover, institutional controls, excavation, and the corrective action contractor is $498,900 (net present value). O&M costs comprise approximately 40% of the net present value.

Soil Cover: Modifying Criteria

State/Support Agency Acceptance: FDEP and the USEPA will have the opportunity to review and comment on this FS.

Community Acceptance: These criteria are generally not completed until after public comments on the RI/FS report and the proposed plan are received.

3.5.4 Alternative 4: Plant-Enhanced Bioremediation

A combination of bioremediation and phytoremediation techniques is used in this alternative to treat contaminated soil in situ. Land use is restricted to industrial, as Site 11 RGs are only protective of site workers.

Plant-Enhanced Bioremediation: Threshold Criteria

Overall Protection of Human Health and the Environment: Plant-enhanced bioremediation is protective of human health as treatment reduces COC concentrations. Bioremediation provides high levels of effectiveness and permanence: residual risks are eliminated once treatment is completed, since degradation is permanent and no untreated wastes are left onsite. As with all biological degradation processes, incomplete degradation is possible, resulting in generation of more toxic byproducts. Bench- and pilot-scale testing will indicate if this is a concern at Site 11.

Compliance with ARARs: This alternative would comply with RGs for future industrial workers. Possible location- and action-specific ARARs include:

- Floodplain requirements as outlined in the *National Environmental Policy Act* (40 CFR Part 6, Appendix A), *Fish and Wildlife Coordination Act* (40 CFR 6.302).

- Storm water discharge requirements as outlined in the *Clean Water Act* (40 CFR 122, 125, 129, 136) and the *Florida Storm Water Discharge Regulations* (FAC 62-25).

Plant-Enhanced Bioremediation: Balancing Criteria

Long-term Effectiveness and Permanence: The bioremediation alternative permanently minimizes risks associated with the contaminated soil by treating it in situ. It is possible that bioremediation will not be able to achieve RGs, as these goals approach the lower limit for sustaining microbial populations. However, contaminant degradation reduces overall risk, and supplementation of traditional bioremediation techniques with phytoremediation promises to enhance removal rates. Arsenic and chromium contamination is not typically amenable to biological activity, but plant uptake may reduce soil concentrations. Institutional controls would be required to restrict access during the remediation period, as well as to limit future site use to industrial.

Reduction of Toxicity, Mobility, or Volume through Treatment: The bioremediation alternative reduces toxicity, mobility, and volume by actively biodegrading site contaminants. This satisfies the statutory preference for using treatment as a principal element. Biodegradation and transformation are irreversible, although stabilization through precipitation or reduction may be reversed if oxidation/reduction conditions in the root zone change. If phytoremediation plants require harvesting to enhance removal rates, the harvested biomass may require special disposal as a treatment residual, depending on contaminant concentrations.

Short-term Effectiveness: The plant-enhanced bioremediation alternative poses minimal dermal or inhalation risks to workers: exposures will occur primarily during grading and planting activities. Any risks posed during installation and maintenance of the remedial system can be controlled with dust control technologies and a site-specific health and safety plan that specifies PPE, respiratory protection, etc. Remedial time frames for bioremediation are not quantifiable without pilot-scale studies. System design, soil and contamination heterogeneities, fate processes of the various constituents, etc. will impact degradation kinetics.

Implementability: Plant-enhanced bioremediation is technically and administratively feasible at Site 11. Phytoremediation is an innovative technology, with significant ongoing research. Bench- and pilot-scale testing will be required to determine degradation rates, amendment requirements, and optimal plant species given site characteristics. Monitoring this remedy is possible through standard analytical protocols; phytoremediation techniques may draw on standard agricultural rather than environmental analyses. Analytical detection limits may restrict determination of low contaminant concentrations due to common matrix interferences. Because PAH contaminant RGs are low (some less than 1 part per million), RGs actually may be lower than analytical detection limits. Degradation may be hard to quantify at low levels, particularly if kinetics are slowed by poor bioavailability.

Cost: The net present worth of plant-assisted bioremediation ranges from $1.3 million to $1.9 million, including institutional controls and annual monitoring. Because combined bioremediation/phytoremediation technologies are innovative, this number is an estimate. Bench- and pilot-scale testing will be required to refine site-specific costs.

Plant-Enhanced Bioremediation: Modifying Criteria

State/Support Agency Acceptance: FDEP and the USEPA will have the opportunity to review and comment on this FS.

Community Acceptance: These criteria are generally not completed until after public comments on the RI/FS report and the proposed plan are received.

3.5.5 Alternative 5: Excavation and Offsite Disposal

The primary element of this alternative is the excavation of soil contaminated above RGs from the site and disposal in an approved landfill. Land use is restricted to industrial to minimize uncontrolled exposure.

Excavation and Offsite Disposal: Threshold Criteria

Overall Protection of Human Health and the Environment: Excavation and offsite disposal protects human health and the environment by removing contaminated soil posing a risk above RGs. Risk to human health and the environment from contaminants exceeding ISCTLs would be eliminated. Short-term risks during implementation from inhalation and dermal contact would be minimal, and could be controlled with common engineering techniques and use of PPE. The alternative could be easily implemented, and would protect current and future site workers and the environment.

Compliance with ARARs: Excavation would meet chemical-specific ARARs for the associated RGs which protect future industrial site workers. Possible location- and action-specific ARARs include:

- Floodplain requirements as outlined in the *National Environmental Policy Act* (40 CFR Part 6, Appendix A), *Fish and Wildlife Coordination Act* (40 CFR 6.302).

- Storm water discharge requirements as outlined in the *Clean Water Act* (40 CFR 122, 125, 129, 136) and the *Florida Storm Water Discharge Regulations* (FAC 62-25).

- USDOT transportation requirements.

- Solid waste disposal requirements (soil is not expected to exhibit hazardous waste characteristics).

Excavation and Offsite Disposal: Balancing Criteria

Long-Term Effectiveness and Permanence: The excavation alternative would remove the contaminated soil from the site and dispose of it in a permitted Subtitle D facility. This alternative would eliminate risk from contaminants exceeding RGs. Soil remaining onsite would not threaten human health under an industrial use scenario. The LUCA will effectively control future land use.

Excavation with disposal in an offsite landfill is a particularly reliable option because soil removal from the site would eliminate risks. Some future liability might be incurred through disposal at a landfill.

Reduction of Toxicity, Mobility, or Volume Through Treatment: The excavation with disposal at an offsite landfill alternative would not satisfy the preference for treatment. Although it is anticipated that excavated soil is non-hazardous, TCLP analysis will be performed for verification. Excavation would eliminate the source area and therefore the contaminants exceeding RGs. This alternative includes removal of approximately 4,140 CY of soil from the site which would be isolated in a secure landfill. Because the source would no longer remain onsite, excavation is considered permanent. Mobility, toxicity and volume would not be reduced and the preference for treatment would not be satisfied.

Short-Term Effectiveness: Excavation would be sufficiently removed from the public to reduce health and safety concerns associated with soil removal. Excavation workers would be exposed to increased particulate emissions and might also have more dermal contact with hazardous constituents. However, worker risks can be reduced with dust control technologies and a site-specific health and safety plan that specifies PPE, respiratory protection, etc.

Implementability: Excavation with offsite landfilling is technically and administratively feasible at Site 11. Removal and offsite disposal have been commonly applied at previous sites. The only potential technical problems that might slow down removal activities are materials handling and disposal (standby time between confirmatory sampling and disposal). Landfill debris, if present within the 0- to 2-foot interval, may require disposal at a debris landfill. Areas to be excavated are readily accessible, and no future remedial actions would be required after this alternative is completed. This alternative would not require any extraordinary services or materials.

Cost: Detailed costs associated with Alternative 5 are presented in Section 3.4.5. Total direct costs for excavation and disposal at a Subtitle D facility are estimated to be $695,870. No O&M costs are associated with this alternative.

Excavation and Offsite Disposal: Modifying Criteria

State/Support Agency Acceptance: FDEP and the USEPA will have the opportunity to review and comment on this FS.

Community Acceptance: These criteria are generally not completed until after public comments on the RI/FS report and the proposed plan are received.

3.6 Site 11 Comparative Analysis of Alternatives

The Site 11 comparative analysis of alternatives is presented in Table 3-14.

Table 3-14
Comparative Analysis of Site 11 Soil Alternatives

Evaluation Criteria	Alternative 1: No action	Alternative 2: Institutional Controls	Alternative 3: Soil Cover	Alternative 4: Plant-Enhanced Bioremediation	Alternative 5: Excavation and Offsite Disposal
		Threshold Criteria			
Protection of human health and the environment (HH&E)	No action is implemented. Because the site's future use is uncontrolled and site contaminants exceed residential standards, there is potential risk to future site residents.	Institutional controls are implemented to restrict land use and therefore minimize uncontrolled exposures. Because locations exceed industrial standards, there is potential risk to current and future site workers.	Soil cover will eliminate the dermal contact and ingestion pathway; the LUCA will limit site use to industrial, thus minimizing uncontrolled exposures.	Bioremediation and phytoremediation degrade and/or immobilize site contaminants to eliminate risks to HH&E. Treatment reduces COC concentrations.	Offsite disposal is a highly effective and reliable way to eliminate risk above RGs. Removal of contaminated medial from the site is protective of current and future site workers.
Compliance with ARARs	Current conditions do not meet RGs. While risk is within USEPA's acceptable risk range, onsite risks exceed FDEP's threshold criteria of 1E-06.	Current conditions do not meet RGs. While risk is within USEPA's acceptable risk range, onsite risks exceed FDEP's threshold criteria of 1E-06.	Soil cover will eliminate surface soil pathways, and therefore meet RGs. Actions would require compliance with storm water and floodplain requirements.	Treatment techniques are effective with PAHs; degradation may achieve RGs. Actions would require compliance with storm water and floodplain requirements.	Removal would comply with RGs, and all actions would require compliance with storm water and floodplain requirements.
		Balancing Factors			
Long-term effectiveness and permanence	None.	Institutional controls are effective at limiting access. The LUCA will need to be maintained.	Covers are effective at eliminating the risk pathway. Maintenance will be required to ensure effectiveness.	Bio- and phytoremediation permanently reduce risks through degradation of site COCs. Although it is possible that as contaminants approach RGs concentrations may not sustain microbial populations, the overall reduction in contaminant concentrations achieved will reduce site risk. Institutional controls will limit future site use.	Excavation and offsite disposal eliminates risk onsite. The LUCA will restrict land use to industrial and eliminate unrestricted exposures.

Table 3-14
Comparative Analysis of Site 11 Soil Alternatives

Evaluation Criteria	Alternative 1: No action	Alternative 2: Institutional Controls	Alternative 3: Soil Cover	Alternative 4: Plant-Enhanced Bioremediation	Alternative 5: Excavation and Offsite Disposal
Reduction of Toxicity, Mobility, or Volume through Treatment	None.	None.	None.	Toxicity is reduce through degradation; phytoremediation can also immobilize contaminants. Degradation is irreversible; precipitates may be solubilized if oxidation/ reduction conditions change.	None.
Short-Term Effectiveness	No risks are associated with the no-action alternative.	No risks are associated with institutional controls.	Implementing the remedy will require less than 1 month; short- term exposures may be reduced by engineering controls and PPE.	Remediation time frames are long, likely greater than 5 years. Short- term exposures may be reduced by engineering controls and PPE.	Implementing the remedy will require less than 1 month; short-term exposures may be reduced by engineering controls and PPE.
Implementability	Technically and administratively feasible. Easily implemented.	Technically and administratively feasible. Easily implemented.	Technically and administratively feasible. Easily implemented.	Phytoremediation is innovative, with significant ongoing research, and pilot work will be required; additional work will be required to scale up the remediation system. Implementability may be constrained by analytical detection limits.	Technically and administratively feasible. Easily implemented.
Cost	**Capital:** none **Annual:** $10,000, every 5 years **PW:** $24,000	**Capital:** $50,000 **Annual:** $10,000, every 5 years **PW:** $74,000	**Capital:** $304,360 **Annual:** $14,060 **PW:** $489,000	**Capital:** $997,130 to $1,584,330 **Annual:** $14,500 **PW:** $1,346,720 to $1,933,920	**Capital:** $695,870 **Annual:** $0 **PW:** $695,870

Table 3-14
Comparative Analysis of Site 11 Soil Alternatives

Evaluation Criteria	Alternative 1: No action	Alternative 2: Institutional Controls	Alternative 3: Soil Cover	Alternative 4: Plant-Enhanced Bioremediation	Alternative 5: Excavation and Offsite Disposal
		Modifying Criteria			
State/Support Agency Acceptance	FDEP and USEPA will have opportunity to review and comment on this technology.	FDEP and USEPA will have opportunity to review and comment on this technology.	FDEP and USEPA will have opportunity to review and comment on this technology.	FDEP and USEPA will have opportunity to review and comment on this technology.	FDEP and USEPA will have opportunity to review and comment on this technology.
Community Acceptance	Community acceptance will be established after the public comment period.	Community acceptance will be established after the public comment period.	Community acceptance will be established after the public comment period.	Community acceptance will be established after the public comment period.	Community acceptance will be established after the public comment period.

4.0 SITE 12 SOIL FEASIBILITY EVALUATION

4.1 Site Description and History

Site 12, currently referred to as the Defense Reutilization and Marketing Office (DRMO) Recyclable Materials Center, is used to store scrap metal. The site is approximately 800 feet northwest of former Chevalier Field and immediately west and upgradient of Site 26. Most of the site is enclosed by a chain-link fence and covered with a large concrete pad where heavy equipment is kept. The limited exposed surface soil is sandy and well-drained. Buildings 455 and 3821 are in the southern portion of the site. Building 455 houses an office, break area, and storage warehouse, while Building 3821 is a storage warehouse.

As noted in Section 1, the low-level radiological waste encountered at Site 12 will be remediated by the Naval Sea Systems Command RASO. RASO will be responsible for assessing, containing, packing, transporting, and disposing of any low-level radiological wastes. No removal actions have occurred at Site 12 after the RI's completion.

4.1.1 Site 12 Surface Soil Comparisons with RSCTLs

Of the 16 locations sampled at Site 12, surface soil at 14 locations exceeded one or more RSCTLs, including arsenic, cadmium, chromium, copper, Aroclor 1260, and various PAHs, as shown in Table 4-1. The most frequent exceedances were for arsenic, Aroclor 1260, and benzo(a)pyrene. Although sample locations are approximately 50 to 100 feet apart, contamination exceeding RSCTLs appears to be widespread across the site, as show in Figure 4-1. Under a residential use scenario, all site soil is assumed to be exposed. As a result, an estimated 3.7 acres is assumed to be contaminated; assuming 2 feet of surface soil, an estimated 11,900 CY of soil exceeding RSCTLs are present at Site 12.

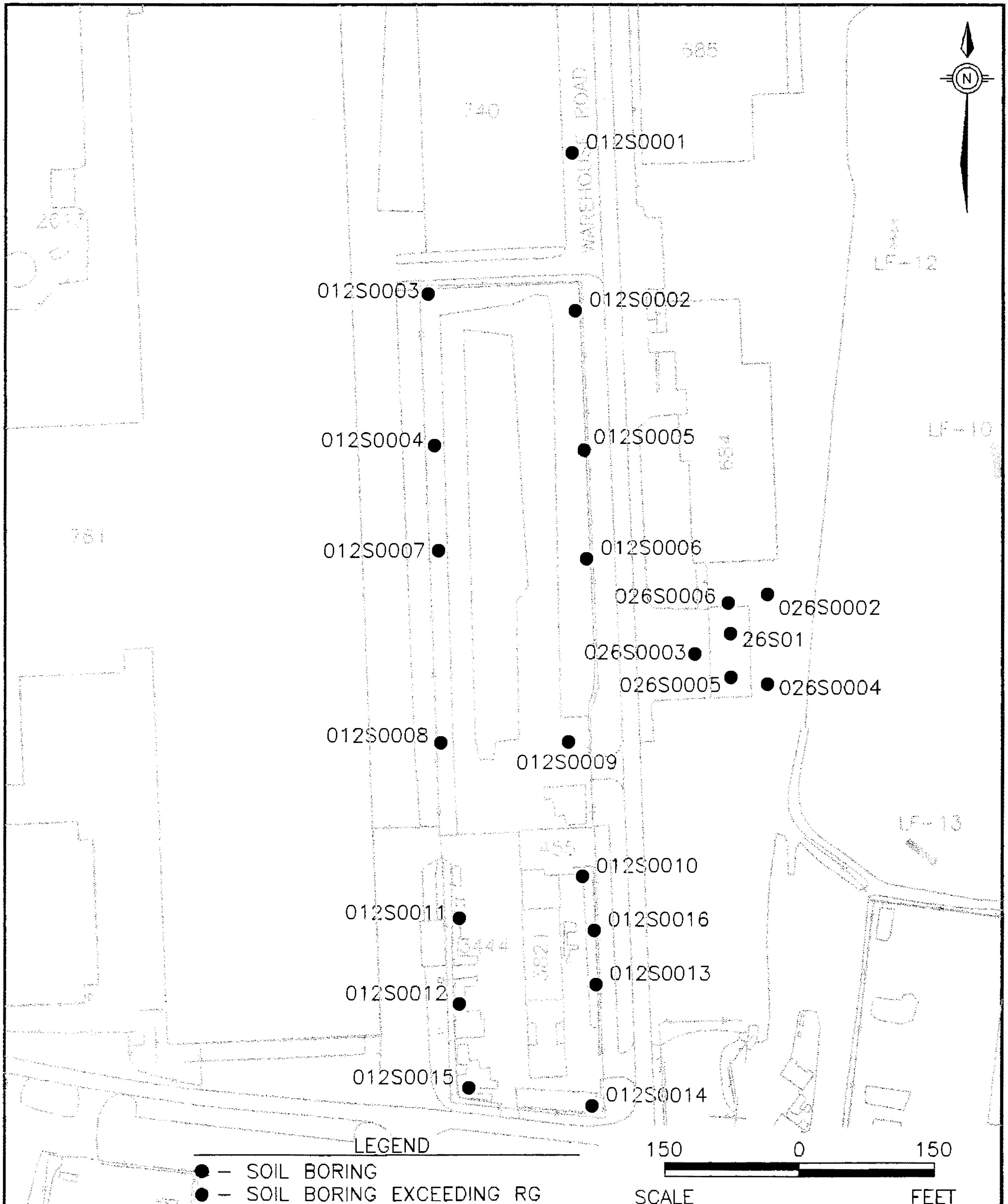


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FIGURE 4-1
SITE 12 AND 26
SOIL BORING LOCATIONS
EXCEEDING ONE OR MORE RSCTLs

DWG DATE: 04/22/99 | DWG NAME: 0970S004

Table 4-1
Site 12 Surface Soil Locations Exceeding RSCTLs

Location	Contaminant	Concentration (in mg/kg)
012-S-0003-01	Copper	268
	Aroclor 1260	12
012-S-0004-01	Aroclor 1260	4.1
012-S-0005-01	Aroclor 1260	0.41 J
012-S-0006-01	Aroclor 1260	0.96
012-S-0007-01	Arsenic	2.4 J
	Copper	125
	Aroclor 1260	15
	Benzo(a)pyrene	0.34
012-S-0008-01	Copper	132
	Aroclor 1260	12
	Benzo(a)pyrene	0.36
012-S-0009-01	Arsenic	1.7 J
	Copper	30 J
	Aroclor 1260	3.9
	Benzo(a)pyrene	1
	Benzo(b)fluoranthene	3.6 J
012-S-0010-01	Arsenic	2.8
	Cadmium	562
	Copper	516
	Benzo(a)anthracene	1.5
	Benzo(a)pyrene	1.9
	Benzo(b)fluoranthene	4.5 J
	Dibenz(a,h)anthracene	0.23
012-S-0011-01	Benzo(a)pyrene	0.18 J
012-S-0012-01	Benzo(a)pyrene	0.14 J
012-S-0013-01	Aroclor 1260	1.4
	Benzo(a)pyrene	0.12 J
012-S-0014-01	Arsenic	2.1 J
012-S-0015-01	Arsenic	1.4 J
	Aroclor 1260	1.3
	Benzo(a)pyrene	0.19 J
012-S-0016-01	Benzo(a)pyrene	0.7
	Dibenz(a,h)anthracene	0.19

Notes:
RSCTLs may be found in Appendix C
J = Concentration is estimated.
mg/kg = milligrams per kilogram

4.1.2 Site 12 Comparison with ISCTLs

Six locations (out of 16) exceeded an ISCTL, as shown in Table 4-2. Contaminants exceeding industrial standards included Aroclor 1260 and benzo(a)pyrene. The locations are concentrated in the northern portion of the site, as shown in Figure 4-2.

The extent of contamination above ISCTLs is approximately 3.7 acres; however, all samples in the northern portion of the site were collected below concrete pavement. Because the pavement is used as a staging area, soil is expected to remain under concrete for current and future industrial use scenarios; therefore, the dermal and ingestion pathways are incomplete and no risk is generated by site soil. However, soil in the southern portion of the site, specifically samples 012-S-0010 and 012-S-0016, is exposed and could pose potential risk to future site workers. Assuming the impacted areas around these isolated exceedances are represented by a 45 ft by 100 ft area, the impacted volumes under an industrial scenario are 330 CY.

Table 4-2
Site 12 Surface Soil Locations Exceeding ISCTLs

Location	Contaminant	Concentration (in mg/kg)
012-S-0004-01	Aroclor 1260	4.1
012-S-0007-01	Aroclor 1260	15
012-S-0008-01	Aroclor 1260	12
012-S-0009-01	Aroclor 1260	3.9
012-S-0010-01	Benzo(a)pyrene	1.9
012-S-0016-01	Benzo(a)pyrene	0.7

Notes:
ISCTLs may be found in Appendix C
mg/kg = milligrams per kilogram

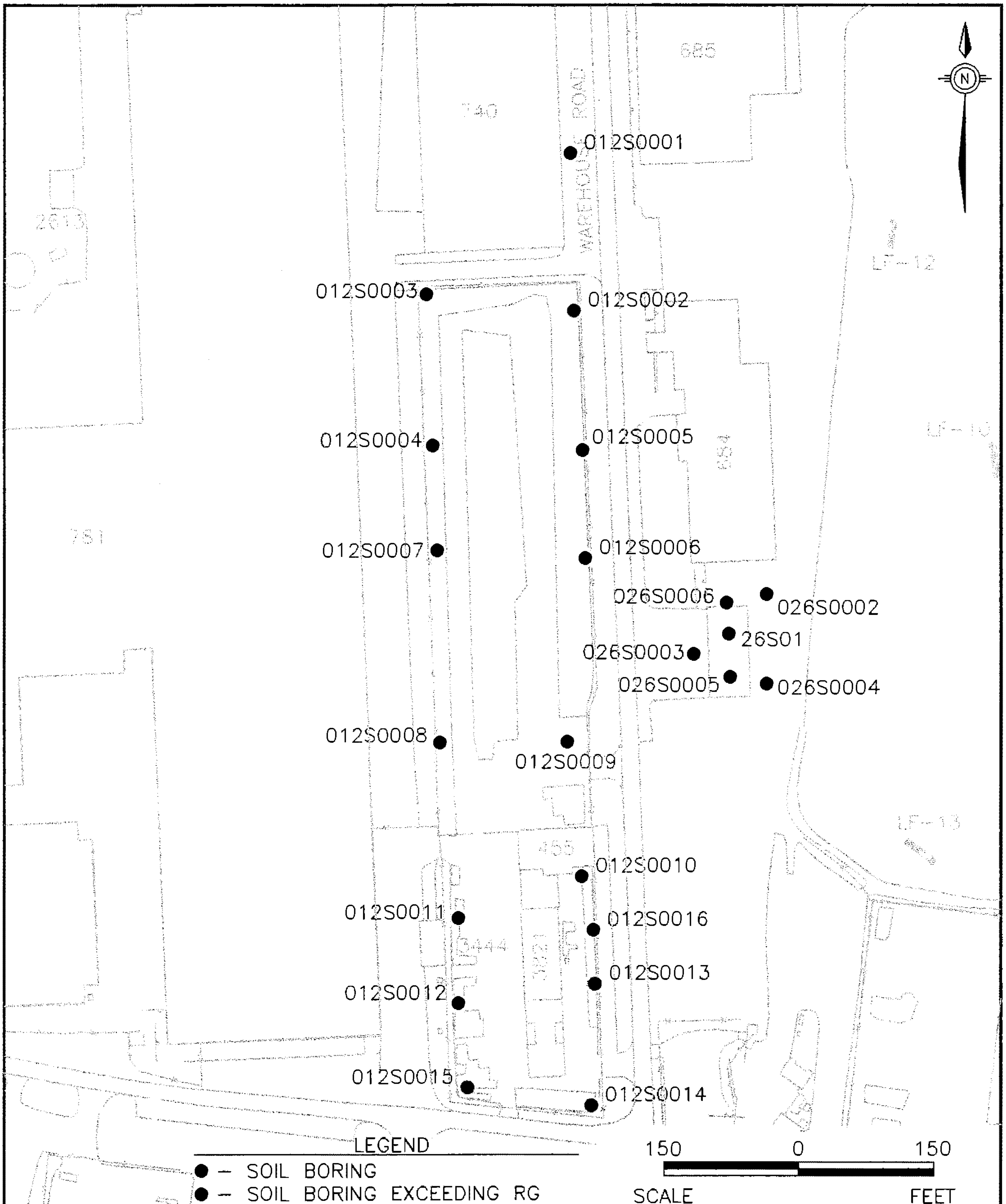

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FIGURE 4-2
SITE 12 AND 26
SOIL BORING LOCATIONS
EXCEEDING ONE OR MORE ISCTLs

DWG DATE: 04/22/99 | DWG NAME: 0970S003

4.1.3 Site 12 Comparison with Leaching Values Protective of Groundwater

SL-PQGs were evaluated with respect to a poor quality aquifer; exceedances are shown in Table 4-3 and Figure 4-3. Cadmium exceeded standards at locations 012-S-0010-01 and 012-S-0016-10. These samples, though adjacent to each other, do not indicate a large cadmium source area in soil because contamination is not continuous throughout the soil column at both locations. Moreover, cadmium was not quantified in groundwater at concentrations above GW-PQG criteria. Therefore, risks from contaminants leaching to groundwater are considered minimal. Cadmium-contaminated soil will not be considered during remedial actions.

Table 4-3
Site 12 Locations Exceeding SL-PQGs

Location	Contaminant	Concentration (in mg/kg)
012-S-0010-01	Cadmium	562
012-S-0016-10	Cadmium	243

Notes:
RSCTLs may be found in Appendix C
mg/kg = milligrams per kilogram

4.1.4 Site 12 Comparison with Leaching Values Protective of Water Bodies

Because Site 12 does not abut any surface water bodies, soil concentrations were not compared with SL-SW criteria.

4.2 Site 12 Remedial Goals

RGs for OU 2 have been proposed for the protection of human health and the environment given current and future land use. OU2 has historically been used for industrial purposes, as described in Section 1; future use is expected to remain the same. Future risk to human health will be minimized by maintaining OU2 as an industrial site. Institutional controls will be required for both soil and groundwater to limit exposures above appropriate criteria.

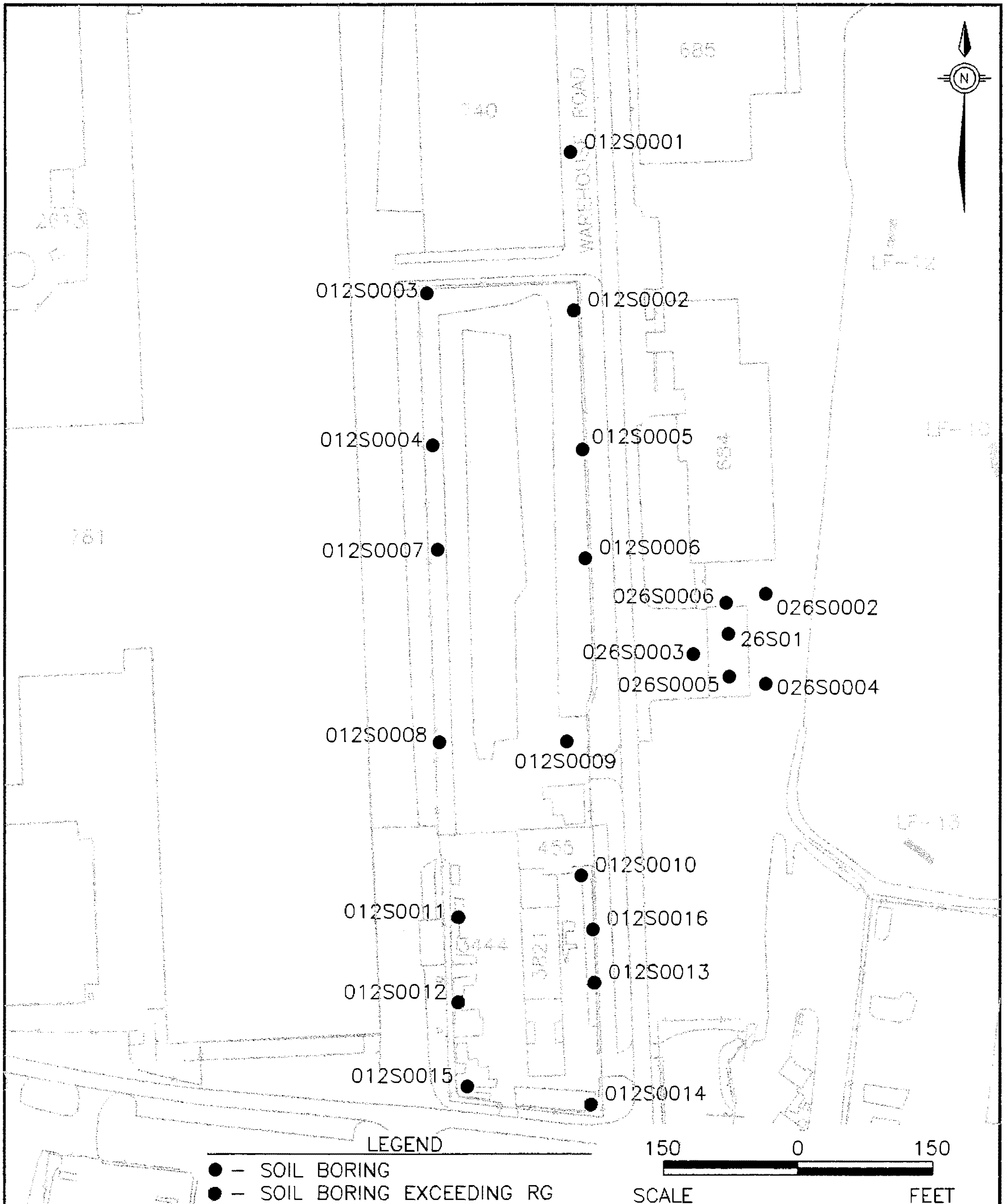

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FIGURE 4-3
SITE 12 AND 26
SOIL BORING LOCATIONS
EXCEEDING ONE OR MORE
SL-PQG CRITERIA

DWG DATE: 04/22/99	DWG NAME: 0970S005

RAOs

- Protect the health of current and future site workers. ISCTLs will be used as RGs.
- Protect the environment by ensuring future soil-to-groundwater transfers are protective of a poor quality aquifer. SL-PQG criteria will be used to determine risk to the underlying aquifer.

4.2.1 Surface Soil Remediation Goals

Surface soil RGs are based on ISCTLs; land use conditions are not expected to change. Table 4-4 presents the RGs for surface soil at OU2.

Table 4-4
Contaminant-Specific Remediation Goals for Surface Soil at Site 12

Contaminant	RG (in mg/kg)
Aroclor-1260	2.1
Benzo(a)pyrene	0.5

Notes:
mg/kg = milligrams per kilogram
RG = remedial goal

4.2.2 Subsurface Soil Remediation Goals

Based on a comparison of site analytical data with Florida SL-PQG criteria, as discussed in Sections 4.1.3 and 4.1.4, contamination detected above SL-PQG and SL-SW criteria does not represent a current or potential source of groundwater contamination. Therefore, no subsurface remediation goals have been established for Site 12.

4.2.3 Site 12 Soil Volumes

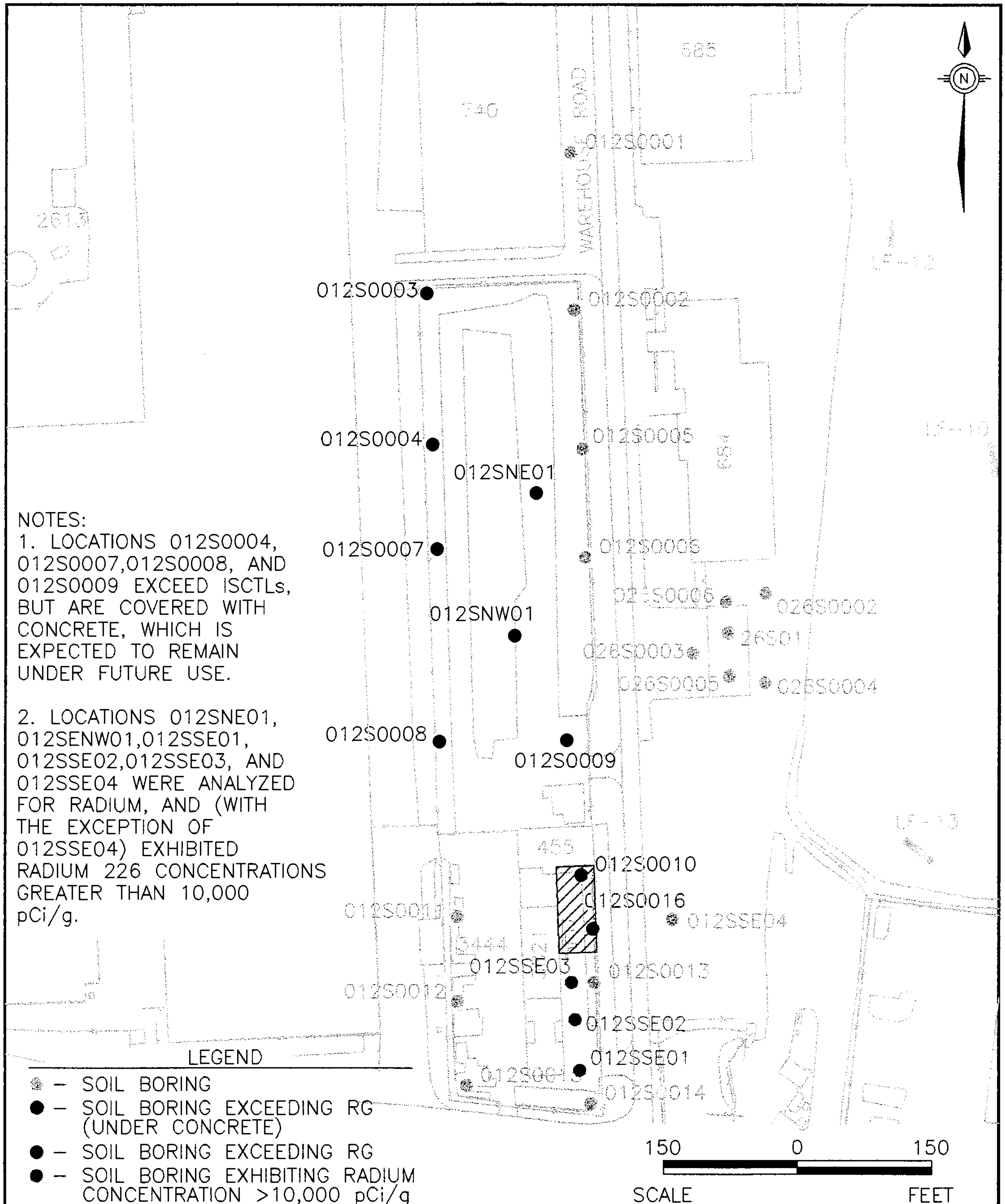
Table 4-5 identifies locations exceeding one or more ISCTLs. This table also identifies surface soil conditions and impacted soil volumes associated with each location.

Table 4-5
Site 12 Surface Soil Volumes Exceeding RGs

Location	Contaminant	Concentration (in mg/kg)	Comment	Soil Volume
012-S-0004-01	Aroclor 1260	4.1	beneath concrete	None.
012-S-0007-01	Aroclor 1260	15	beneath concrete	None.
012-S-0008-01	Aroclor 1260	12	beneath concrete	None.
012-S-0009-01	Aroclor 1260	3.9	beneath concrete	None.
012-S-0010-01	Benzo(a)pyrene	1.9	Exposed surface soil	012-S-0010 and 012-S0016 combined area approximately 45 ft by 100 ft by 2 ft. Total volume 330 CY.
012-S-0016-01	Benzo(a)pyrene	0.7	Exposed surface soil	012-S-0010 and 012-S0016 combined area approximately 45 ft by 100 ft by 2 ft. Total volume 330 CY.

Notes:
mg/kg = milligram per kilogram
ft = foot
CY = cubic yard

Land use at Site 12 is expected to remain the same. Existing site features such as concrete and asphalt may reasonably be expected to remain during future activities. Because the risk exposure pathways at locations 012-S-0004, 012-S-0007, 012-S-0008, and 012-S-0009 are not complete, these borings will not be considered during the FS remedial action given the industrial use scenario. Therefore, the total soil volume impacted at Site 12 is approximately 330 CY. The areal distribution of contaminated media is shown in Figure 4-4. Note that immediately south of this area radium contamination contributes significant human health risk. Radium contamination will be addressed by RASO.



NOTES:
1. LOCATIONS 012S0004, 012S0007,012S0008, AND 012S0009 EXCEED ISCTLs, BUT ARE COVERED WITH CONCRETE, WHICH IS EXPECTED TO REMAIN UNDER FUTURE USE.

2. LOCATIONS 012SNE01, 012SENW01,012SSE01, 012SSE02,012SSE03, AND 012SSE04 WERE ANALYZED FOR RADIUM, AND (WITH THE EXCEPTION OF 012SSE04) EXHIBITED RADIUM 226 CONCENTRATIONS GREATER THAN 10,000 pCi/g.

LEGEND
- SOIL BORING
- SOIL BORING EXCEEDING RG (UNDER CONCRETE)
- SOIL BORING EXCEEDING RG
- SOIL BORING EXHIBITING RADIUM CONCENTRATION >10,000 pCi/g

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FIGURE 4-4
SITE 12 AND 26
SOIL AREAS EXCEEDING RGs

DWG DATE: 04/22/99 | DWG NAME: 0970S002

4.3 Site 12 Soil Technologies Screening

Table 4-6 presents various remedial technologies applicable to PAHs in soil. This table evaluates each technology's applicability to Site 12, and is used to screen out technologies that are infeasible given site conditions. As discussed in Section 2, technologies have been screened for implementability, effectiveness, and cost.

The technologies retained for use at Site 12 after screening are:

- No Action, as required by the NCP.
- Institutional controls, which will be needed to maintain the industrial-use classification
- Capping
- Excavation with offsite disposal

Table 4-6 includes screening comments for each technology; the rationale for discarding other potential technologies is discussed in the following paragraphs.

A key factor in evaluating remedial options is the contaminated media's proximity to radiological contamination. Because the area that poses risk is adjacent to radium contamination at Site 12, it is possible that contamination may overlap. In situ techniques may be futile if soil is subsequently excavated by RASO, or if these actions interfere with RASO's removal. Similarly, if soil is excavated, treated, and replaced, there is a chance that the RASO removal may excavate the clean soil for disposal. Conversely, if radium-contaminated soil is inadvertently treated during Site 12 remedial actions, cross-contamination of soil and equipment could occur. Any actions considered should be integrated with RASO plans for Site 12 soil. The following comments assume complete segregation of chemical- and radium-contaminated soil.

Table 4-6
Soil Technology Screening — Site 12

Technology	Description	Implementability	Effectiveness	Cost
CONTAINMENT				
Surface Cap	Capping is a containment technology that will limit human contact with soil and reduce infiltration of rainwater through contaminated soil. Capping materials include soil, asphalt, and concrete.	Currently, the hard shell area impacted at Site 12 is used as a parking lot. This area may be paved easily. Any actions that could change surface features, however, should be coordinated with radioactive soil remediation plans being developed by RASO.	Caps eliminate the ingestion/ inhalation/contact pathway, and therefore are effective at reducing risk to human health. With ongoing maintenance, the long-term effectiveness of a cap is high. Capping is an effective means of eliminating risk pathways, but it does not meet any preference for treatment, nor does it reduce contaminant toxicity, mobility, or volume.	Because this cap is intended only to eliminate a risk pathway and not to isolate waste or reduce infiltration, a multi-layer cap is not required. Costs for common capping material, such as soil, asphalt, or concrete, are comparatively low. Maintenance costs are also low.
IN SITU TREATMENT TECHNOLOGIES				
Bioremediation	Naturally occurring microbes are stimulated by amending contaminated soils to enhance biodegradation. Nutrients, oxygen, hydrogen peroxide, and other amendments may enhance biodegradation and contaminant desorption from subsurface materials. Amendments may be added through solution (such as water), or they may be mixed into the soil using tillers or rippers. When mechanical mixing is required, such as with in situ land farming applications, in situ bioremediation effectiveness is limited at depth. Similarly, effectiveness may be limited if deeper zones exhibit preferential pathways and nutrient/amendment delivery is irregular. Bioremediation may occur in aerobic and anaerobic conditions. In some cases, commercially obtained microbes may be used to supplement native polulations.	Bioremediation may be technically implementable at Site 12; contamination is limited to the top 2 feet bgs, and thus may easily be controlled. However, given current and future site use, implementation of bioremediation at Site 12 will likely be difficult. Impacted areas posing risk are currently used for parking and access to adjacent buildings. The access required for amendment and monitoring would likely limit the usefulness of this area during the remediation effort. Any actions should be coordinated with radioactive soil remediation plans being developed by RASO.	Bioremediation is likely to be effective at Site 12 given that contamination is limited to the top 2 feet. Shallow contamination is easily monitored and controlled. The porous nature of the impacted media may facilitate uniform amendment delivery. In situ bioremediation most readily treats non-halogenated volatile, semivolatile, and fuel hydrocarbons. However, degradation of PAH compounds is typically slower than more amenable compounds, such as BTEX. Although high concentrations of heavy metals, highly chlorinated organics, long-chain hydrocarbons, or inorganic salts are likely to be toxic to microorganisms, these conditions do not exist at Site 12. Bioremediation enhances biodegradation, and therefore is considered a destructive technology.	Bioremediation costs are typically variable because the need for amendments is highly site specific. However, in situ bioremediation costs are typically lower than other insitu technologies such as SVE. This option is not likely to be cost effective given the small volume of contaminated soil at Site 12.

Table 4-6
Soil Technology Screening — Site 12

Technology	Description	Implementability	Effectiveness	Cost
IN SITU TREATMENT TECHNOLOGIES (continued)				
Bioventing	Air is either extracted from or injected into the unsaturated soils to increase oxygen concentrations and stimulate biological activity. Bioventing is applicable for any contaminant that more readily degrades aerobically than anaerobically. This process is used to deliver amendments to zones deeper than what can be managed by bioremediation practices alone. Flow rates are much lower than soil vapor extraction, minimizing volatilization and release of contaminants to the atmosphere. Where preferential pathways exist in the vadose zone, air flow may not reach all contaminated media.	Bioventing is not technically implementable to Site 12, given that contamination is limited to the 0- to 2-foot interval. Administrative implementability is also limited given current and future site use. Any actions should be coordinated with radioactive soil remediation plans being developed by RASO.	Bioventing is unlikely to be more effective than natural degradation processes at this site, given that surface soil is already highly oxygenated. Bioventing enhances biodegradation, and therefore is considered a destructive technology.	Bioventing is relatively inexpensive, though ongoing use of blowers and ancillary piping will require O&M. This option is not likely to be cost effective given the small volume of contaminated soil at Site 12.
Phytoremediation	Phytoremediation is the use of plants to remove, contain, and/or degrade contaminants. Examples include: enhanced rhizosphere biodegradation, phytoaccumulation, phytodegradation, and phytostabilization. Climatic or hydrologic conditions may restrict the rate of growth of the remediation plants.	Phytoremediation may be technically implementable at Site 12; contamination is limited to the top 2 feet, and thus there are likely a wide variety of plants which may be used to remediate site soil. However, given current and future site use, implementation of phytoremediation at Site 12 will likely be difficult. Impacted areas posing risk are currently used for parking and access to adjacent buildings. Phytoremediation would eliminate the use of these areas. Any actions should be coordinated with radioactive soil remediation plans being developed by RASO. Additionally, due to time required for remediation, plans for future site use may be impacted by phytoremediation.	Phytoremediation is an innovative technology that may be effective at Site 12 given that contamination is limited to the top 2 feet, well within the root zones of some plants. Shallow contamination is easily monitored and controlled. Although high concentrations of hazardous materials can be toxic to plants, contaminant concentrations at Site 12 are not excessive. Phytoremediation may be a destructive remediation technology, depending on the type of plants used. It may also be used as a containment or immobilization strategy, binding contaminants in soil or biomass. However, there is concern that phytoremediation is reversible. Additionally, plants that have died or which are removed from the site may require special management or handling due to concentrated contaminants within the biomass.	Costs for phytoremediation are expected to be low compared with other in situ techniques. Maintenance costs are also expected to be relatively low, consisting of monitoring and watering costs. This option is not likely to be cost effective given the small volume of contaminated soil at Site 12.

Table 4-6
Soil Technology Screening — Site 12

Technology	Description	Implementability	Effectiveness	Cost
IN SITU TREATMENT TECHNOLOGIES (continued)				
In Situ Solidification/ Stabilization	In situ stabilization immobilizes contaminants by mixing site soil with portland cement, lime, or a chemical reagent to reduce the mobility of the contaminant. Large augering equipment is used to mix soils in place with the reagent. This technology will likely leave a solid mass (similar to concrete) onsite.	This technology is technically implementable at Site 12. Contaminated soil is limited to the 0- to 2-foot interval, which is easily mixed. The stabilized mass may be left in place, and use of the area for parking and access may continue. Any actions should be coordinated with radioactive soil remediation plans being developed by RASO.	Solidification/stabilization can be an effective containment strategy for PAH compounds. However, this technology works better for inorganics including radionuclides. Some organic-contaminated soils may delay or inhibit reactions necessary for solidification. Long-term, the stabilized mass can degrade, particularly if subject to repeated abuse. Solidification/stabilization is not a permanent treatment technology and does not remove or destroy contaminants; rather, contaminants are immobilized. Treated media typically must be managed long term (e.g., through institutional controls and monitoring).	Solidification/stabilization costs typically vary given the stabilizing material required (e.g., fly ash, portland cement, etc.). However, these costs are typically low compared with destructive in situ options. This option is not likely to be cost effective given the small volume of contaminated soil at Site 12.
EX SITU TREATMENT TECHNOLOGIES				
Solid-phase biodegradation • Biopiles • White rot fungus • Landfarming	Excavated soils are mixed with amendments, nutrients, enzymes, or fillers and placed in aboveground enclosures. Mixing may be required, as in a traditional landfarming application. Conversely, biopiles may be used simply to deliver oxygen uniformly throughout a large pile. Ex situ biological systems may be designed to degrade specific compounds and maintain specified degradation conditions (aerobic vs. anaerobic). Mechanical mixing, such as tilling or turning of windrows, may be required.	Although technically implementable, the small volume of contaminated soil present at Site 12 may limit the administrative implementability of this technology. Existing structures and utilities may impede or restrict excavation. Moreover, a large amount of space is required for solid phase ex situ bioremediation. Any actions should be coordinated with radioactive soil remediation plans being developed by RASO.	Ex situ bioremediation systems may be tailored to the specific contaminant requiring treatment. Biodegradation is typically limited to organic compounds, and heavy metals may be toxic to microorganisms. Remediation half-lives for PAHs may be slower than more degradable compounds, such as BTEX, which may extend the remediation time frame. Solid phase bioremediation is a permanent , destructive technology.	Ex situ solid phase bioremediation is inexpensive compared with other ex situ techniques. However, given the need to design specific nutrient amendments and process control systems, more recalcitrant organics are typically more expensive to treat. This option is likely not cost effective given the small volume of soil contaminated at Site 12.

Table 4-6
Soil Technology Screening — Site 12

Technology	Description	Implementability	Effectiveness	Cost
EX SITU TREATMENT TECHNOLOGIES (continued)				
Slurry Phase Biological Treatment	Slurry-phase bioreactors containing co-metabolites and specially adapted microorganisms can be used to treat halogenated VOCs and SVOCs, pesticides, and PCBs. An aqueous slurry is created by combining soil with water and other additives. The slurry is mixed continuously to keep solids suspended and microorganisms in contact with the soil contaminants. Upon completion of the process, the slurry is dewatered and the treated soil is disposed of.	Although technically implementable, the small volume of contaminated soil present at Site 12 may limit the administrative implementability of this technology. Existing structures and utilities may impede or restrict excavation. Moreover, a large amount of space is required for slurry phase ex situ bioremediation. Any actions should be coordinated with radioactive soil remediation plans being developed by RASO.	Slurry-phase bioreactors are used primarily to treat nonhalogenated SVOCs and VOCs in excavated soils or dredged sediments. Ex situ bioremediation systems may be tailored to the specific contaminant requiring treatment. Biodegradation is typically limited to organic compounds, and heavy metals may be toxic to microorganisms. Remediation half-lives for PAHs may be slower than more degradable compounds, such as BTEX, which may extend the remediation time frame. Slurry phase bioremediation is a permanent, destructive technology.	Ex situ slurry phase bioremediation is expensive compared with other biological techniques, due to the controls and materials handling required. This option is not likely to be cost effective given the small volume of contaminated soil at Site 12.
Soil Washing • Chemical Extraction • Acid Extraction • Solvent Extraction • Separation Techniques	Excavated soil is washed with aqueous-based solutions to separate contaminants sorbed onto fine particles from the rest of the soil matrix. The fractions of soil to be treated are processed in a slurry with specific leachant mixtures to ionize target metals. The solvent/waste mixture is then treated further to develop a concentrated leaching solution which may be treated or disposed off offsite. Traditional soil washing options may also include separation techniques which concentrate contaminated solids through physical and chemical means. These processes seek to detach contaminants from their medium (e.g., soil, sand, or other binding material). Gravity separation, magnetic separation, and sieving/physical separation are examples of this technology.	Although technically implementable, the small volume of contaminated soil present at Site 12 may limit the administrative implementability of this technology. Existing structures and utilities may impede or restrict excavation. Soil washing systems will require operational space as well as possible water and sewer connections. Any actions should be coordinated with radioactive soil remediation plans being developed by RASO.	Overall, this technology is effective at removing SVOCs and inorganics. It is less effective at treating VOCs. In general, acid extraction techniques are suitable for treating soils contaminated by heavy metals. Solvent extraction has been shown to be effective in treating soils containing primarily organic contaminants, but is generally least effective on very high molecular-weight organic and very hydrophilic substances. Soils with higher clay content may reduce extraction efficiency and require longer contact times. High humic content in soil may require pretreatment. It may be difficult to remove organics adsorbed to clay-size particles. Soil washing is a permanent treatment technology which removes contaminants from soil to another medium (e.g., solvent, carbon, etc.). Treatment residuals then may require treatment or disposal. Soil washing solvents may also pose environmental risks.	Soil washing is typically an expensive remediation alternative because of the highly site-specific design requirements and the need to treat and/or dispose of the leaching solvent. Magnetic separation is specifically used on heavy metals, radionuclides, and magnetic radioactive particles, such as uranium and plutonium compounds. This option is not likely to be cost effective given the small volume of contaminated soil at Site 12.

Table 4-6
Soil Technology Screening — Site 12

Technology	Description	Implementability	Effectiveness	Cost
		EX SITU TREATMENT TECHNOLOGIES (continued)		
Chemical/ Physical Oxidation • permanganate flooding • Fenton's reagent • Wet air oxidation • Supercritical water oxidation	Chemical oxidation is a process in which the oxidation state of a contaminant is increased while the oxidation state of the reactant is decreased. The reactant can be another element, including the oxygen molecule, or it may be a chemical species containing oxygen, such as hydrogen peroxide or chlorine dioxide. In the case of physical oxidation technologies, wet air oxidation and supercritical water oxidation both use high pressure and temperature to treat organic contaminants.	Chemical oxidation is not technically implementable at Site 12, given the low soil volumes. Administrative implementability is also limited given current and future site use. Any actions should be coordinated with radioactive soil remediation plans being developed by RASO. Iron and manganese in the soil will compete with contaminants for oxygen.	This technology is effective in treating media contaminated with halogenated and non-halogenated volatiles and semivolatiles, PCBs, pesticides, cyanides, and volatile and nonvolatile metals. Wet air oxidation can treat hydrocarbons and other organic compounds. Supercritical water oxidation is applicable for PCBs and other stable compounds. Oxidation is a permanent treatment technology in which contaminants are destroyed.	Costs for chemical oxidation processes may be comparable to soil washing costs, given the need to construct and operate ex situ reactors, and the need to control reagents and reactor conditions. Costs may vary widely with the type of oxidation technique implemented. The small soil volumes at Site 12 likely render this technology cost-prohibitive.
Ex Situ Solidification/ Stabilization	Contaminants are physically bound or encased within a stabilized mass, or chemical reactions are induced with stabilizing agents. The contaminants are not removed or destroyed, but their mobility is reduced. Examples of S/S technologies include: bituminization, emulsified asphalt, modified sulfur cement, polyethylene extrusion, pozzolan/portland cement, radioactive waste solidification, sludge stabilization, and soluble phosphates.	Ex situ stabilization/ solidification is the best-demonstrated technology for multiple compounds. It is technically implementable, and often required to render contaminants non-hazardous before offsite disposal. Site contaminants are non-hazardous PAHs, and it is unlikely that it will be necessary to render these concentrations lower to meet treatment standards.	This technology works well for inorganics including radionuclides. Although organic-contaminated soil may be treated with solidification/stabilization, some organics can delay or inhibit reactions necessary for solidification. Solidification/ stabilization is not a permanent treatment technology and does not remove or destroy contaminants; rather, contaminants are immobilized. Treated media typically must be managed appropriately, i.e., landfilled or contained onsite. Where used as asphalt or similar covers, degradation due to normal asphalt weathering should be considered.	Solidification/stabilization costs typically vary given the stabilizing material required (e.g., fly ash, portland cement, etc.). However, ex situ stabilization/ solidification is inexpensive, compared with other ex situ technologies. This option is not likely to be cost effective given the small volume of contaminated soil at Site 12.

Table 4-6
Soil Technology Screening — Site 12

Technology	Description	Implementability	Effectiveness	Cost
		EX SITU TREATMENT TECHNOLOGIES (continued)		
Incineration/ Pyrolysis	Incineration burns contaminated sediment at high temperatures (1,600° - 2,200°F) to volatilize and combust organic contaminants. A combustion gas treatment system must be included with the incinerator. The circulating bed combustor, fluidized bed reactor, infrared combustor, and rotary kiln are several types of incinerators. Pyrolysis chemically changes contaminated sediment by heating it in the absence of air. Pyrolysis can be achieved by limiting oxygen to rotary kilns and fluidized bed reactors. Molten salt destruction is another example of pyrolysis.	Incineration/ pyrolysis is not technically implementable at Site 12, given that soil volumes are very low -- likely inadequate for a trial burn. The lead agency will likely be reluctant to construct an incineration unit for a small-volume, short-term project. Administrative implementability will be limited by the need for submitting documentation and testing the unit's compliance with ARARs. Administrative implementability is also limited given current and future site use. Any actions should be coordinated with radioactive soil remediation plans being developed by RASO. Highly abrasive feed can damage the processor unit. The technology requires drying the soil to achieve less than 1% moisture content.	Incineration may be effective in treating organic-contaminated soil, but not for soil with metals as the primary contaminants. The target contaminant groups for pyrolysis are SVOCs and pesticides. Pyrolysis is not effective in either destroying or physically separating inorganics from the contaminated medium. Volatile metals may be removed by the higher temperatures, but are not destroyed. Incineration is a permanent treatment technology; COCs are destroyed during treatment.	Incineration/ pyrolysis are typically very expensive remedial options compared with other ex situ remediation. The small soil volumes at Site 12 likely render this technology cost prohibitive.

Table 4-6
Soil Technology Screening — Site 12

Technology	Description	Implementability	Effectiveness	Cost
		EX SITU TREATMENT TECHNOLOGIES (continued)		
Thermal Desorption	Soil is generally heated between 200° and 1,000°F to separate VOCs, water, and some SVOCs from the solids into a gas stream. The organics in the gas stream must be treated or captured. Thermal desorption may be used at high or low temperatures depending on the volatility of the contaminants.	Thermal desorption is technically implementable at Site 12. Some thermal desorbers may be regulated as incinerators, depending on construction. Testing and optimization would be required. Administrative implementability will likely be limited given current and future site use. Any actions should be coordinated with radioactive soil remediation plans being developed by RASO. Highly abrasive feed can damage the processor unit. Although clay and silty soils and soil with high humic content increase reaction time due to binding of contaminants, this problem would not be anticipated for Site 12.	Thermal desorption units are effective at removing primarily organic contaminants. Residence time and temperature inside the unit can be varied to volatilize recalcitrant organics. Inorganic contaminants or metals that are not particularly volatile will not be effectively removed by thermal desorption. Vapor phase organics must be concentrated and treated or otherwise disposed of. Thermal desorption is a permanent treatment technology which will eliminate risk by removing COCs from site soil.	Although less expensive than other ex situ thermal treatment methods, thermal desorption is still comparatively expensive. Costs increase with the degree of materials handling, pre-and post- treatment, and off-gas controls required. The small soil volumes at Site 12 likely render this technology cost-prohibitive.

Table 4-6
Soil Technology Screening — Site 12

Technology	Description	Implementability	Effectiveness	Cost
EX SITU TREATMENT TECHNOLOGIES (continued)				
Excavation and Offsite Disposal	Contaminated soil is excavated and disposed of offsite at a licensed waste disposal facility.	Excavation with offsite disposal is both technically and administratively implementable at Site 12. Contaminated media can be removed and disposed offsite. The excavated areas can then be backfilled with clean fill with minimal impact to operations at adjacent buildings. Testing will be required before the soil is disposed of; TCLP results may impact disposal options. Transporting the soil through populated areas may affect community acceptance; however, given the small volumes anticipated at Site 12, this is not expected to be an issue. Any actions which may change surface features, should be coordinated with radioactive soil remediation plans being developed by RASO.	Excavation with offsite disposal is expected to be an effective remediation option. It is effective for all contaminants because the risk pathway is eliminated. This is a permanent remedial technology.	Costs for excavation and offsite disposal vary, depending on whether waste is classified as hazardous. However, compared with other options (including treatment or disposal at an incineration facility), landfilling is relatively less expensive.

In situ bioremediation techniques and phytoremediation were discarded because of land use considerations at Site 12 and minimal soil volumes. Current and future land use is expected to remain industrial. The impacted area is used for parking and access area to adjacent buildings and activities. Typical bioremediation technologies would require some degree of tillage, moisture control, or other amendment which would render the area nonfunctional during the remediation period. In addition, because PAHs are slower to degrade than other contaminants, remediation time frames will be comparatively longer than other technologies.

Similarly, in situ and ex situ solidification/stabilization were discarded as possible technologies because of adjacent land use and projected soil volumes. Solidification/stabilization is primarily used to minimize leaching and contaminant mobility, which are not problematic for PAHs. Mobilizing solidification/stabilization contractor to the site for approximately 330 cubic yards of soil would likely be more expensive than other implementable soil technologies.

Ex situ reactor-based treatment, such as solid and slurry phase biodegradation, soil washing, and chemical oxidation were also eliminated based on the small volume of soil requiring treatment. Each of these technologies requires infrastructure, which may range from haybales and polyethylene liners for a small landfarming unit, to mixers and contact chambers for a soil washing unit. Once again, the construction of treatment units for such a small volume of soil is likely to be cost-prohibitive.

Thermal treatments, such as incineration, pyrolysis, and thermal desorption, although effective for organic compounds, were discarded because of the high costs and implementation obstacles associated with meeting ARARs. If thermal treatment is identified at another site as a viable option, consolidation might be considered. However, contamination across OU 2 is significantly low enough that other treatment options will likely meet the statutory preference for treatment.

4.4 Site 12 Assembly of Alternatives

The following alternatives have been retained for Site 12 soil.

- Alternative 1: No Action
- Alternative 2: Institutional controls
- Alternative 3: Asphalt Cap
- Alternative 4: Excavation with Offsite Disposal

4.4.1 Alternative 1: No Action

Under this alternative, no changes would be made to existing site operations or exposure scenarios. While the current and projected land use for this site is expected to remain institutional, there are no institutional controls to guarantee the exposure pathway would remain industrial. Without controls, a residential scenario must be assumed in which all existing pavement and buildings are removed.

Implementability

The no-action alternative could be easily implemented. The Navy would be required to perform a 5-year review to assess adequacy of the alternative.

Effectiveness

The no-action alternative is not effective at protecting human health, as contaminants above residential and industrial SCTLs are left onsite. As discussed in the BRA, if residential exposures occur, Site 12 soil presents a combined soil ingestion/contact pathway risk of 1E-04 to potential future site residents; this risk is at the upper end of the allowable range cited in the NCP (1E-06 to 1E-04), and exceeds the FDEP threshold criteria of 1E-06.

Cost

Table 4-7 presents the costs associated with the no-action alternative.

Table 4-7
Alternative 1 — No Action

Action	Quantity	Cost per Unit	Total Cost
Five Year Review	LS	$10,000	$10,000
Present value subtotal at 6% discount over 30 years			$24,400
Total Cost			**$24,400**

Notes:
LS = lump sum
Cost based on review once every five years for 30 years.

4.4.2 Alternative 2: Institutional Controls

No remedial actions will be implemented under this alternative. LUCAs would be implemented to limit access and property use to industrial/commercial, thereby limiting unacceptable exposure to contamination. Because the majority of exceedances are beneath concrete pavement in the northern section of Site 12, the LUCA would also limit intrusive activities in this area.

This alternative does not require any changes to existing activities, since current land use at Site 12 is industrial. However, controls would be required to minimize exposures which could include maintenance activities in impacted areas. Notification of the Base Environmental office would be required to ensure proper instruction before invasive activities begin.

Implementability

Implementation of this alternative does not require any innovative technologies or construction activities; ongoing operations would not be interrupted. This alternative would require the Navy to control site access and keep its use industrial/commercial. Site access can be controlled through the LUCA and/or warnings against excavation. The site would be inspected annually to ensure compliance with the LUCA. If the property was no longer under direct Navy control, development of a deed restriction would be necessary. The Navy has base planners and attorneys on staff with experience to develop and implement proper institutional controls for Site 12. The possibility of transferring Site 12 to civilian control is highly unlikely in the near future; therefore, proper controls can be implemented through planning.

The NCP requires any alternative which leaves contamination onsite to be reevaluated every 5 years to ensure its adequacy. Therefore, the institutional controls alternative would require the Navy to establish a monitoring program.

Effectiveness

Institutional controls at Site 12 would limit unacceptable exposure to surface soil contamination. Under current site conditions, surface soil exceeds ISCTLs at six sample locations, two of which are exposed. This alternative would not provide any additional effectiveness for the current use scenario, but would provide long-term effectiveness by restricting future use and access. This alternative still poses some risk to site workers, because two locations exceeding ISCTLs for PAHs are exposed surface soil. However, workers would be exposed only during activities in which they contact surface soil. No risks are posed during implementation of institutional controls.

Overall, this alternative ensures that:

- Contaminants in the northern portion of Site 12 remain under concrete paving, which currently eliminates the risk pathway for site workers.

- Intrusive activities are not permitted near borings 012S0010 and 012S0016, where concentrations exceeded ISCTLs. This area currently is used for parking and access to adjacent buildings.

This alternative does not provide more protection to site workers than the current scenario, but it does eliminate the future resident exposure pathway by excluding the property from residential use. Likely exposures will be less than the worst case assumed in SCTL development (see *Technical Report: Development of Soil Cleanup Target Levels*, ERC Hearing Draft, May 1999).

As demonstrated in the BRA, Site 12 meets the NCP's allowable risk range of 1E-06 to 1E-04 for the industrial scenario, with a combined ingestion/contact pathway risk of 1.7E-05 for future site workers; however, this exceeds FDEP's risk threshold of 1E-06.

Cost

The total present-worth cost of the institutional controls alternative is estimated at $74,400.

As shown in Table 4-8, the Navy assumes implementation of institutional controls will cost approximately $50,000, which is the estimated cost for completing the necessary documentation and annual review of site use. In addition a 5 year reevaluation of site conditions will be required for 30 years, as per the NCP. The estimated cost for each reevaluation is $10,000 per event; assuming a 6% discount rate over 30 years, the present worth of reevaluation requirements is approximately $24,400.

Table 4-8
Alternative 2 — Costs for Institutional Controls

Action	Quantity	Cost per Unit	Total Cost
Five Year Review	LS	$10,000	$10,000
Present value subtotal at 6% discount over 30 years			$24,400
Institutional Controls (LUCA and Signs)	LS	$50,000	$50,000
Total Cost			**$74,400**

Notes:
LS = Lump sum
Cost based on review once every five years for 30 years.

4.4.3 Alternative 3: Asphalt Cover

Installing an asphalt cover would reduce the risk of site workers contacting areas of exposed contaminated soil, thus eliminating exposure pathways. Institutional controls would also be incorporated to restrict future access to contaminated soil. Limited excavation would eliminate risk from isolated areas of contaminated soil.

Remedial activities for the asphalt cover would consist of:

- Implementing institutional controls (LUCA)
- Confirmatory sampling
- Site preparation
- Cover placement

Cover construction would consist of a 4- to 8- inch asphalt pavement placed over contaminated soil areas. The pavement would be sloped to direct runoff toward open or grassy areas where percolation may occur. Confirmation sampling would help delineate the extent of soil in which contaminant concentrations exceed the RG to ensure that all contaminated soil is covered.

Implementability

Cover construction with institutional controls is technically feasible at Site 12. The site is suitable for asphalt or concrete covering to protect site workers from contaminated soil and to control runoff. Land use restrictions may be used to implement institutional controls. The Site 12 area that would be covered are shown in Figure 4-5; the total area to be covered is approximately 4,500 square feet (ft^2). Actual areas to be covered would be determined in the field following confirmation sampling.

Effectiveness

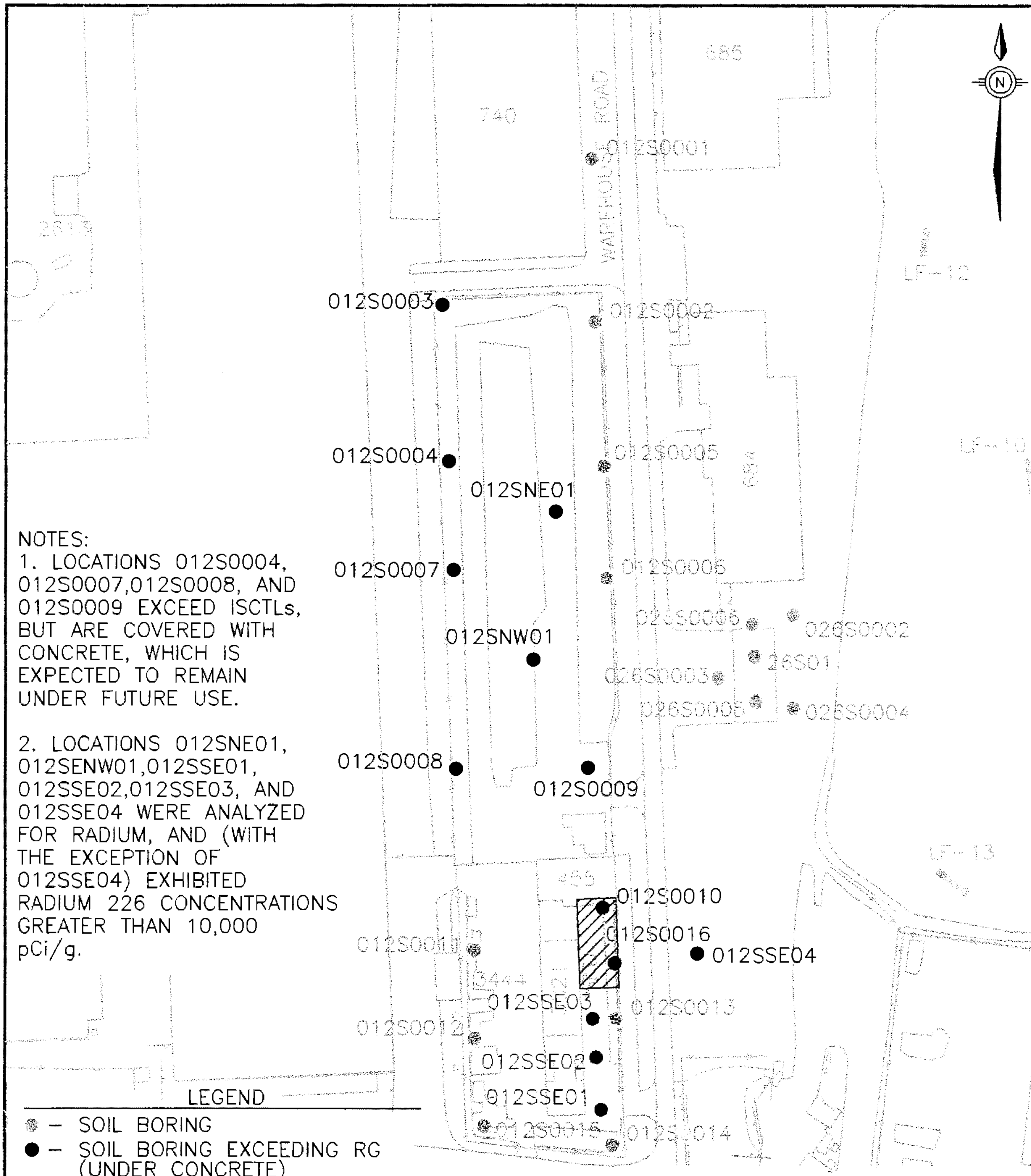
Covers provide reliable protection against dermal contact with and ingestion of contaminated soil. They isolate contaminants exceeding risk and guidance concentrations in environmental media, but are not designed to manage solid or hazardous waste. Confirmation sampling will ensure the entire area exceeding RGs is covered. Once the cover is in place, institutional controls would help ensure continued cover effectiveness and regular maintenance would be required.

Cost

Table 4-9 presents the capital costs associated with installation of an asphalt cover and institutional controls.

4.4.4 Alternative 4: Excavation with Offsite Disposal

This alternative involves excavating surface soil in which contaminants exceed compound-specific RGs and disposing of it offsite. Approximately 330 yd^3 of surface soil would be removed from the site to eliminate threats to current or future industrial site workers through dermal contact and ingestion exposure pathways. Since soil removal is based on meeting ISCTLs, institutional controls (the LUCA) will be used to ensure that future use remains industrial. Proposed removal areas are shown in Figure 4-4.



NOTES:
1. LOCATIONS 012S0004, 012S0007,012S0008, AND 012S0009 EXCEED ISCTLs, BUT ARE COVERED WITH CONCRETE, WHICH IS EXPECTED TO REMAIN UNDER FUTURE USE.

2. LOCATIONS 012SNE01, 012SENW01,012SSE01, 012SSE02,012SSE03, AND 012SSE04 WERE ANALYZED FOR RADIUM, AND (WITH THE EXCEPTION OF 012SSE04) EXHIBITED RADIUM 226 CONCENTRATIONS GREATER THAN 10,000 pCi/g.

LEGEND
- SOIL BORING
- SOIL BORING EXCEEDING RG (UNDER CONCRETE)
- SOIL BORING EXCEEDING RG
- SOIL BORING EXHIBITING RADIUM CONCENTRATION >10,000 pCi/g

DRAFT FEASIBILITY STUDY
OPERABLE UNIT 2
NAS PENSACOLA
PENSACOLA, FLORIDA

FIGURE 4-5
SITE 12 AND 26
PROPOSED COVER LOCATION

DWG DATE: 04/22/99 | DWG NAME: 0970S001

Table 4-9
Alternative 3 — Costs for Asphalt Cover

Action	Quantity	Cost per Unit	Total Cost
Capital Costs for Asphalt Cover			
Mobilization/Demobilization	LS	$500	$500
Grading/site preparation	500 yd^2	$1.50/yd^2$	$750
Asphalt/Concrete Surface (8" depth)	4,500 ft^2	$1.76/ft^2$	$7,920
Engineering/Oversight	LS	20% cost	$1,500
Contingency/Miscellaneous	LS	25% cost	$1,930
Subtotal			$12,600
Operation and Maintenance Cost			
Maintain cover (30 years)	500 yd^2	$2/yd^2$	$1,000
Inspection	LS	$500	$500
Subtotal			$1,500
Present value at 6% discount over 30 years			$20,650
Confirmation Sampling	4 samples (plus 2 QA/QC samples)	$250/sample	$1,500 *
Institutional Controls (LUCA and signs)		LS	$50,000
Subtotal			$51,500
Remedial Contractor Cost			$100,000
Total Cost			$184,750

Notes:
LS = Lump sum
yd^2 = square yard
* Assumes one sample will be collected along each edge of the contaminated area. Samples will be analyzed for SVOCs.

Because soil PAH concentrations are relatively low (1 to 10 part-per-million range), Site 12 soil is not expected to be considered hazardous waste. Remedial activities would consist of:

- Implement institutional controls (LUCA)
- Excavation
- Confirmatory sampling
- Backfill
- Transport of excavated material offsite
- Landfill at a Subtitle D facility

Confirmation samples would be collecte from surface soil surrounding the excavation to ensure complete removal of soil in which contaminant concentrations exceed RGs.

After the contaminated soil is removed, clean backfill would be placed in the excavated areas and graded. TCLP analysis would be conducted to determine if the excavated soil exhibits toxicity characteristics.

Implementability

This alternative is both technically and administratively feasible at Site 12. Excavation is performed frequently and is a reliable method to remove contaminated soil within given boundaries. No technology-specific regulations apply to excavation and offsite disposal (i.e., landfilling) alternatives. Except for implementing land use restrictions, no long-term maintenance or monitoring would be required after soil in which contaminant concentrations exceed RGs has been removed. Based on groundwater elevation data presented in the RI report, groundwater is not expected to pose a problem during excavation.

Administrative considerations would include:

- Transportation and disposal of contaminated soil must adhere to USDOT regulations and requirements.
- Scheduling would be required to reduce costs for roll-off boxes and downtime while transporting the soil from Site 12 to the disposal facility.
- Daily operations at the surrounding activities will likely be interrupted on a short-term basis by access problems during the removal process.

No capacity limitations are expected at the landfill, given low projected soil volumes.

Effectiveness

Excavation with offsite disposal would protect the environment at Site 12 by reducing the amount of soil in which contaminant concentrations exceed RGs.

Short-term inhalation, ingestion, and contact risks to site workers (excavation crew) would temporarily increase during excavation but should last only until remedial actions are complete. Onsite actions will require health and safety practices consistent with PAH contamination and dust generation. These risks will be reduced through proper use of PPE and engineering controls. Because no residential areas are adjacent to Site 12, there are no short-term risks to the surrounding community. No onsite long-term risks are associated with this alternative because exposed soil in which contaminants exceed the FDEP ISCTL would be removed.

Cost

Table 4-10 presents the capital costs associated with excavation and offsite disposal at a Subtitle D facility.

Table 4-10
Alternative 4 — Costs for Excavation and Offsite Disposal

Action	Quantity	Cost per Unit	Total Cost
Excavation	330 CY	$20/CY	$6,600
Confirmation Sampling	5 samples (plus 3 QA/QC samples)	$250/sample	$1,250 [a]
Backfill	430 CY	$15/CY	$6,450 [b]
Subtotal			$14,300
Subtitle D Disposal Facility			
Transportation	22 trucks (assuming 20 yd^3 each) hauling 30 miles	$3.50/loaded mile	$2,310 [b]
Soil Disposal	500 tons	$36/ton	$18,000 [c]
Engineering/Oversight	LS	20% cost	$4,060
Contingency/Miscellaneous	LS	25% cost	$5,080
Subtotal			$29,450
Institutional Controls (LUCA and signs)			$50,000
Remedial Contractor Cost			$100,000
Total			$193,750

Notes:
LS = Lump sum
[a] = Four samples will be collected around each contaminated boring. Samples will be analyzed for SVOCs.
[b] = Assumes 30% fluff after excavation.
[c] = Assumes 1.5 tons per cubic yard.

4.5 Site 12 Detailed Analysis of Soil Alternatives

The following alternatives have been retained for Site 12 soil:

- Alternative 1: No Action
- Alternative 2: Institutional Controls
- Alternative 3: Asphalt Cover
- Alternative 4: Excavation and Offsite Disposal

Each alternative is evaluated according to the nine criteria discussed in Section 2, which have been divided into the three categories — threshold, balancing, and modifying.

4.5.1 Alternative 1: No Action

The no-action alternative for Site 12 involves no active remedial effort. No actions will be taken to contain, remove, or treat soil contamination above RGs. Soil will remain in place. No engineering or institutional controls will be implemented. The no-action alternative provides a baseline against which other alternatives can be compared.

No Action: Threshold Criteria

Overall Protection of Human Health and the Environment: The no-action alternative provides no additional protection of human health and the environment. This alternative assumes that future use is residential. Site 12 soil exceeds RSCTLs at 14 locations. These exceedances would remain onsite, unmitigated. Under an uncontrolled use scenario, the BRA calculated site risks to be 1.0E-4 (residential exposure).

Compliance with ARARs: Alternative 1 does not comply with the RGs developed for Site 12; moreover, contaminants will pose risk under an uncontrolled future use scenario. Florida Proposed Rule 62-777 is a potential ARAR for OU 2. No location- or action-specific ARARs are triggered by the No Action alternative.

No Action: Balancing Criteria

The primary balancing criteria are the technical criteria on which the detailed analysis is based.

Long-term Effectiveness and Permanence: Long-term effectiveness of Alternative 1 is minimal. Soil volumes and concentrations would remain unchanged. In addition, this alternative does not reduce the magnitude of residual risk and lacks treatment actions that would provide permanence.

Any controls currently in place at the site — military security and limited access to/use of the site — would remain. If use were unrestricted, no controls would be in place to protect potential receptor groups (i.e., residents).

Reduction of Toxicity, Mobility, or Volume Through Treatment: This alternative would not reduce soil contaminant mobility, toxicity, or volume. Contaminants would remain untreated and in place.

Short-Term Effectiveness: Short-term effectiveness assesses an alternative's effect on human health and the environment while it is being implemented. There are no such effects from the no-action alternative.

Implementability: The no-action alternative is technically feasible and easily implemented. No construction, operation, or reliability issues are associated with this alternative. Current access controls — including military security and limited personnel access to the site — have historically been reliable. No administrative coordination, offsite services, materials, specialists, or innovative technologies are required. There are no implementation risks associated with Alternative 1.

Cost: Costs include a site review and report preparation every five years for 30 years. Each review and report are estimated to cost $10,000, with a present-worth of $24,000 for the 30-year period.

No Action: Modifying Criteria

The modifying criteria are assessed formally after the public-comment period. However, the criteria are factored into identifying the preferred alternatives, as far as they are known.

State/Support Agency Acceptance: FDEP and the USEPA will have the opportunity to review and comment on this FS.

Community Acceptance: These criteria are generally not completed until after public comments on the RI/FS report and the proposed plan are received.

4.5.2 Alternative 2: Institutional Controls

The institutional controls alternative for Site 12 involves no active remedial effort. No actions will be taken to contain, remove, or treat soil contamination above RGs. Soil would remain in place and institutional controls would be incorporated into the LUCA to ensure Site 12 remains an industrial use area.

Institutional Controls: Threshold Criteria

Overall Protection of Human Health and the Environment: The institutional controls alternative provides additional protection of human health and the environment by reducing the potential for uncontrolled site access. By restricting use to industrial/commericial, future risks from residential ingestion of or contact with soil are eliminated. However, soil contamination at Site 12 exceeds industrial RGs and poses a threat under a future worker scenario. The BRA calculated a risk of 1.7E-05 for site workers under an industrial use scenario.

Compliance with ARARs: Alternative 2 does not comply with the RGs established for Site 12; Florida Proposed Rule 62-777 is a potential ARAR. No location- or action-specific ARARs are triggered by the institutional controls alternative. Contaminated soil would remain above the RGs.

Institutional Controls: Balancing Criteria

The primary balancing criteria are the technical criteria on which the detailed analysis is based.

Long-Term Effectiveness and Permanence: The long-term effectiveness of institutional controls is limited to the ability to control access to contaminated soil. Soil volumes and concentrations would remain unchanged, and there are no treatment actions that would provide permanence.

Reduction of Toxicity, Mobility, or Volume Through Treatment: The institutional controls alternative would not reduce the mobility, toxicity, or volume of soil contaminants. Contaminants would remain untreated and in place onsite.

Short-Term Effectiveness: Short-term effectiveness assesses an alternative's effect on human health and the environment while it is being implemented. There are no short-term effects resulting from the institutional controls alternative.

Implementability: The institutional controls alternative is technically feasible and easily implemented. No construction issues are associated with this alternative. Current access controls — including military security and limited personnel access to the site — have historically been reliable and will be supplemented through land use restrictions. Administrative coordination is required to implement institutional controls, but no offsite services, materials, specialists, or innovative technologies would be required. There are no implementation risks with Alternative 2.

Cost: Costs include soil monitoring and report preparation every five years for 30 years, plus the cost of establishing the institutional controls. Each sampling and reporting event is estimated to cost $10,000, with a present worth of $24,400 for the 30-year period. Providing the necessary institutional controls is estimated to be a one-time cost of $50,000, for a total cost of $74,400.

Institutional Controls: Modifying Criteria

The modifying criteria are assessed formally after the public-comment period. However, the criteria are factored into identifying the preferred alternatives, as far as they are known.

State/Support Agency Acceptance: FDEP and the USEPA will have the opportunity to review and comment on this FS.

Community Acceptance: These criteria are generally not completed until after public comments on the RI/FS report and the proposed plan are received.

4.5.3 Alternative 3: Asphalt Cover

This alternative uses a physical barrier to cover the two exposed locations where contaminants exceed RGs. In conjunction with the cover alternative, land use will be restricted to industrial to minimize uncontrolled exposure and prevent cover disturbance.

Asphalt Cover: Threshold Criteria

Overall Protection of Human Health and the Environment: The asphalt cover would eliminate the threat of dermal and ingestive contact for current and future site workers. Contaminated soil would be left onsite indefinitely and the cover maintained to ensure adequate protection.

This alternative would protect human health and the environment by physically eliminating receptor pathways and controlling access through land use restrictions. Cover construction and maintenance would be easily implemented, and current site controls (site security, access control, and fencing) and the LUCA would be adequate to ensure minimal disturbance. Short-term risks during implementation from inhalation and dermal contact would be minimal, and could be controlled using common engineering techniques and use of PPE.

Compliance with ARARs: The asphalt cover with associated institutional controls would comply with RGs for future industrial workers. The potential for contact with soil in which contaminants exceed ISCTLs is eliminated by removing the primary pathways.

The cover would isolate or eliminate contaminants exceeding RGs in environmental media, but not manage solid or hazardous waste. Site grading would need to comply with federal, state, and local air emissions and storm water control regulations. Remedial actions at Site 12 may trigger the following ARARs:

- Floodplain requirements as outlined in the *National Environmental Policy Act* (40 CFR Part 6 Appendix A), *Fish and Wildlife Coordination Act* (40 CFR 6.302).

- Storm water discharge requirements as outlined in the *Clean Water Act* (40 CFR 122, 125, 129, 136) and the *Florida Storm Water Discharge Regulations* (FAC 62-25).

Asphalt Cover: Balancing Criteria

Long-Term Effectiveness and Permanence: An asphalt cover would effectively reduce site worker dermal or ingestive contact with contaminated soil, and would require inspection and maintenance. Asphalt covers are generally reliable containment controls; if the asphalt degraded or was removed, repairs could be made to re-establish the cover's integrity.

This alternative eliminates residual risk to site workers by managing Site 12 as an industrial site and restricting land use. The use of these covered soil areas would be controlled institutionally.

Reduction of Toxicity, Mobility, or Volume Through Treatment: Constructing an asphalt cover at Site 12 would not remove, treat, or remediate the contaminated soil; it provides containment only. The cover is considered reversible, because contaminants exceeding RGs under the cover would remain onsite; if the cover fails because of poor maintenance, contaminants may be exposed. This alternative would not reduce toxicity, mobility, or volume through treatment, nor would it satisfy the statutory preference for treatment.

Short-Term Effectiveness: Adverse impacts to the surrounding environment are not anticipated during cover construction; engineering controls would be applied to manage storm water runoff and siltation. Once design plans are approved, actual cover construction would be expected to take less than one month. During construction, workers would be at risk for dermal or ingestive contact with site contaminants; however, this risk would be reduced by proper site work practices and use of PPE.

Implementability: An asphalt cover with institutional controls and limited excavation is technically and administratively feasible. This alternative could be readily applied at the site, because the proposed areas to be covered are easily accessible. Current access controls have been reliable and will be supplemented through the LUCA, and thus implementing this alternative would merely involve placement of the cover and implementation of the LUCA. Future monitoring and maintenance would involve periodic visual inspections and repairing any damage or degradation. Repairs are easily implemented, and asphalt covering would not require any extraordinary services or materials. It is possible that radium contamination and PAH contamination overlap; a radiological sampling event should be performed before any active Site 12 remedy is implemented, to better define the extent of radium contamination. All sampling and remediation activities should be coordinated with RASO.

Cost: Costs for this alternative are detailed in Section 4.4.3. The total cost for Alternative 3 including the cover, institutional controls, excavation, and the corrective action contractor is $184,250 (net present value). O&M costs comprise approximately 10% of the net present value.

Asphalt Cover: Modifying Criteria

State/Support Agency Acceptance: FDEP and the USEPA will have the opportunity to review and comment on this FS.

Community Acceptance: These criteria are generally not completed until after public comments on the RI/FS report and the proposed plan are received.

4.5.4 Alternative 4: Excavation and Offsite Disposal

The primary element of this alternative is the excavation of soil contaminated above RGs from the site and disposal in an approved landfill. Land use is restricted to industrial to minimize uncontrolled exposure.

Excavation and Offsite Disposal: Threshold Criteria

Overall Protection of Human Health and the Environment: Excavation and offsite disposal protects human health and the environment by removing contaminated soil posing a risk above RGs. Risk to human health and the environment from contaminants exceeding ISCTLs would be eliminated. Short-term risks during implementation from inhalation and dermal contact would be minimal, and could be controlled with common engineering techniques and use of PPE. The alternative could be easily implemented, and would protect current and future site workers and the environment.

Compliance with ARARs: Excavation would meet chemical-specific ARARs for the associated RGs which protect future industrial site workers. Possible location- and action-specific ARARs include:

- Floodplain requirements as outlined in the *National Environmental Policy Act* (40 CFR Part 6 Appendix A), *Fish and Wildlife Coordination Act* (40 CFR 6.302).

- Storm water discharge requirements as outlined in the *Clean Water Act* (40 CFR 122, 125, 129, 136) and the *Florida Storm Water Discharge Regulations* (FAC 62-25).

- USDOT transportation requirements.

- Solid waste disposal requirements (soil is not expected to exhibit hazardous waste characteristics).

Cross-contamination with radium-contaminated soil would trigger mixed waste rules and associated requirements for disposal of radiological waste.

Excavation and Offsite Disposal: Balancing Criteria

Long-Term Effectiveness and Permanence: The excavation alternative would remove the contaminated soil from the site and dispose of it in a permitted Subtitle D facility. This alternative would eliminate risk from contaminants exceeding RGs. Soil remaining onsite would not threaten human health under an industrial use scenario. The LUCA will effectively control future land use.

Excavation with disposal in an offsite landfill is a particularly reliable option, because soil removal from the site would eliminate risks. Some future liability might be incurred through disposal at a landfill.

Reduction of Toxicity, Mobility, or Volume Through Treatment: The excavation with disposal at an offsite landfill alternative would not satisfy the preference for treatment. Although it is anticipated that excavated soil is non-hazardous, TCLP analysis will be performed for verification.

Excavation would eliminate the source area and therefore the contaminants exceeding RGs. This alternative includes the removal of approximately 330 CY of soil from the site which would be isolated in a secure landfill. Because the source would no longer remain onsite, excavation is considered permanent. Mobility, toxicity and volume would not be reduced and the preference for treatment would not be satisfied.

Short-Term Effectiveness: Excavation would be sufficiently removed from the public to reduce health and safety concerns associated with soil removal. Excavation workers would be exposed to increased particulate emissions and might also have more dermal contact with hazardous constituents. However, worker risks can be reduced with dust control technologies and a site-specific health and safety plan that specifies PPE, respiratory protection, etc. The health and safety plan should also address the presence of radiological contamination at Site 12 and the possibility of cross-contamination.

Implementability: Excavation with offsite landfilling is technically and administratively feasible at Site 12. Removal and offsite disposal have been commonly applied at previous sites. The only potential technical problems that might slow down removal activities are materials handling and disposal (standby time between confirmatory sampling and disposal). Landfill debris, if present within the 0- to 2-foot interval, may require disposal at a debris landfill. Areas to be excavated are readily accessible, and no future remedial actions would be required after this alternative is completed. It is possible that radium contamination and PAH contamination overlap; a radiological sampling event should be performed before any active Site 12 remedy is implemented, to better define the extent of radium contamination. All sampling and remediation activities should be coordinated with RASO.

This alternative would not require any extraordinary services or materials.

Cost: Detailed costs associated with Alternative 4 are presented in Section 4.5.4. Total direct costs for excavation and disposal at a Subtitle D facility are estimated to be $193,750. No O&M costs are associated with this alternative. Costs could increase significantly if cross-contamination with radium-contaminated soil occurs.

Excavation and Offsite Disposal: Modifying Criteria

State/Support Agency Acceptance: FDEP and the USEPA will have the opportunity to review and comment on this FS.

Community Acceptance: These criteria are generally not completed until after public comments on the RI/FS report and the proposed plan are received.

4.6 Site 12 Comparative Analysis of Alternatives

The Site 12 comparative analysis of alternatives is presented in Table 4-11.

Table 4-11
Comparative Analysis of Site 12 Soil Alternatives

Evaluation Criteria	Alternative 1: No action	Alternative 2: Institutional Controls	Alternative 3: Asphalt Cover	Alternative 4: Excavation and Offsite Disposal
Threshold Criteria				
Protection of human health and the environment (HH&E)	No action is implemented. Because the site's future use is uncontrolled and site contaminants exceed residential standards, there is potential risk to future site residents.	Institutional controls are implemented to restrict land use and therefore minimize uncontrolled exposures. Because locations exceed industrial standards, there is potential risk to current and future site workers.	Asphalt cover will eliminate the dermal contact and ingestion pathway, the LUCA will limit site use to industrial, thus minimizing uncontrolled exposures.	Offsite disposal is a highly effective and reliable way to eliminate risk above RGs. Removal of contaminated medial from the site is protective of current and future site workers.
Compliance with ARARs	Current conditions do not meet RGs. While risk is within USEPA's acceptable risk range, onsite risks exceed FDEP's threshold criteria of 1E-06.	Current conditions do not meet RGs. While risk is within USEPA's acceptable risk range, onsite risks exceed FDEP's threshold criteria of 1E-06.	Asphalt cover will eliminate surface soil pathways, and therefore meet RGs. Actions would require compliance with storm water and floodplain requirements.	Removal would comply with RGs, and all actions would require compliance with storm water and floodplain requirements.
Balancing Factors				
Long-term effectiveness and permanence	None.	Institutional controls are effective at limiting access. The LUCA will need to be maintained.	Covers are effective at eliminating the risk pathway. Maintenance will be required to ensure effectiveness.	Excavation and offsite disposal eliminates risk onsite. The LUCA will restrict land use to industrial and eliminate unrestricted exposures.
Reduction of Toxicity, Mobility, or Volume through Treatment	None.	None.	None.	None.
Short-Term Effectiveness	No risks are associated with the no-action alternative.	No risks are associated with institutional controls.	Implementing the remedy will require less than 1 month; short-term exposures may be reduced by engineering controls and PPE.	Implementing the remedy will require less than 1 month, short- term exposures may be reduced by engineering controls and PPE.
Implementability	Technically and administratively feasible. Easily implemented.	Technically and administratively feasible. Easily implemented.	Technically and administratively feasible. Easily implemented.	Technically and administratively feasible. Easily implemented.

Table 4-11
Comparative Analysis of Site 12 Soil Alternatives

Evaluation Criteria	Alternative 1: No action	Alternative 2: Institutional Controls	Alternative 3: Asphalt Cover	Alternative 4: Excavation and Offsite Disposal
Balancing Factors (continued)				
Cost	Capital: none Annual: $10,000, every 5 years PW: $24,000	Capital: $50,000 Annual: $10,000, every 5 years PW: $74,000	Capital: $164,100 Annual: $1,500 PW: $184,750	Capital: $193,750 Annual: $0 PW: $193,750
Modifying Criteria				
State/Support Agency Acceptance	FDEP and USEPA will have opportunity to review and comment on this technology.	FDEP and USEPA will have opportunity to review and comment on this technology.	FDEP and USEPA will have opportunity to review and comment on this technology.	FDEP and USEPA will have opportunity to review and comment on this technology.
Community Acceptance	Community acceptance will be established after the public comment period.	Community acceptance will be established after the public comment period.	Community acceptance will be established after the public comment period.	Community acceptance will be established after the public comment period.

Notes:
NC = no criteria
NA = not applicable

5.0 SITE 25 SOIL FEASIBILITY EVALUATION

5.1 Site 25 Description and History

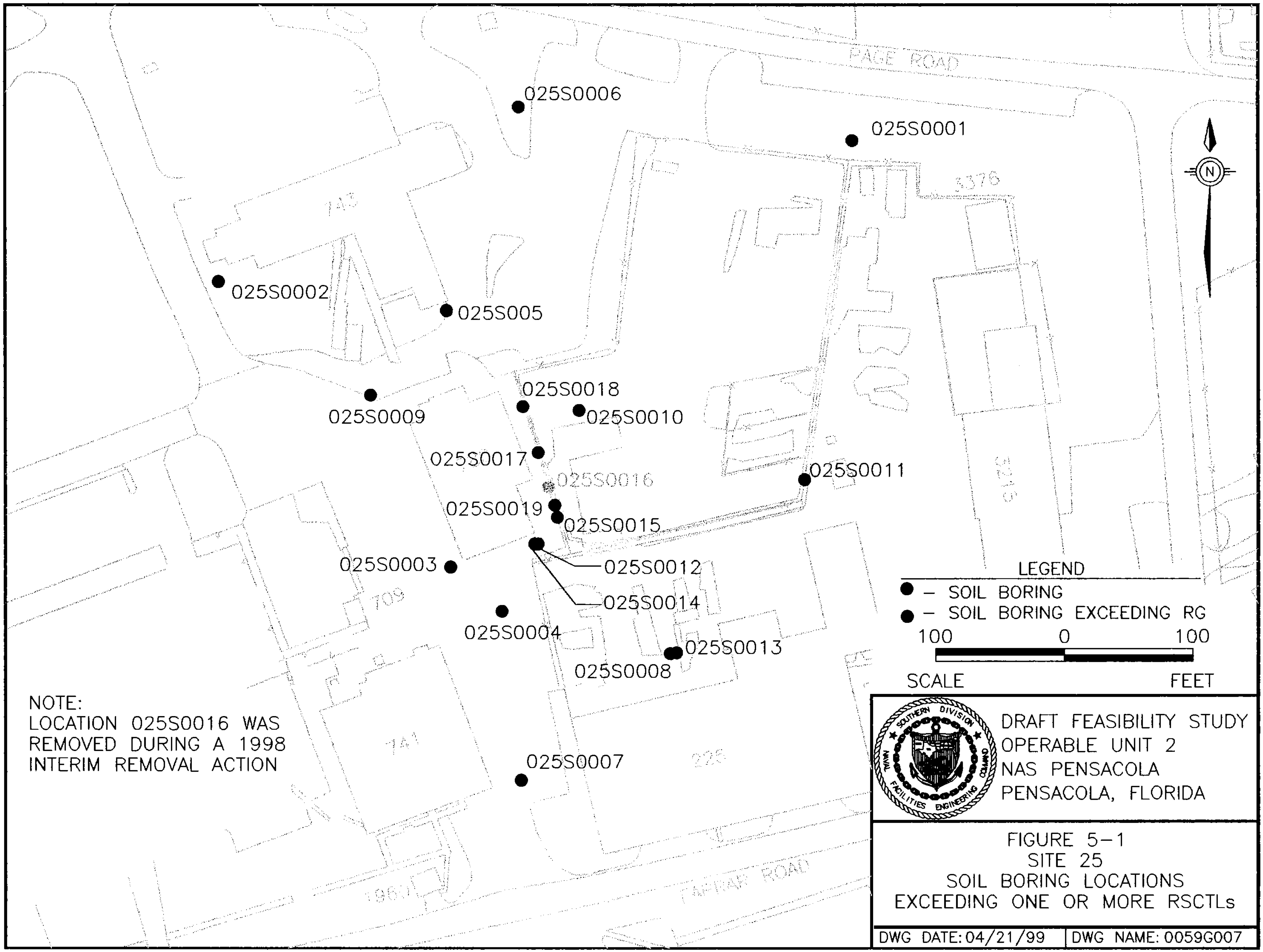
This approximately 50- by 50-foot concrete-paved area is in the eastern portion of NAS Pensacola, immediately east of Murray Road and north of Farrar Road. Building 780 currently houses the Joint Oil Analysis Laboratory, used for quality assurance analysis of oil from aircraft and vehicles. The site is flat with land surface elevations averaging approximately 22 to 25 feet above msl. Where exposed, site surface soil is sandy and well-drained.

PCBs exceeding FDEP PRGs were excavated from Site 25 in the March 1998 Interim Removal Action by the Navy's remedial action contractor (Contract Number N624767-93-D-0936, Delivery Order #0071). A 6 foot by 6 foot by 2 foot area with Aroclor-1260 quantified at 3.1 mg/kg was excavated around sample location 025-S-0016. This soil was disposed of at the Springhill Regional Landfill as Class D waste.

5.1.1 Site 25 Surface Soil Comparison with RSCTLs

Seven out of 19 locations at Site 25 exceeded one or more RSCTLs, as shown in Table 5-1. Samples were collected from the 0 to 6 inch, 6 to 12 inch, and 1 to 2 foot intervals, designated as -00, -01, and -02 respectively. The primary exceedances included arsenic, lead, Aroclor 1260, and PAHs. Chromium exceeded its RSCTL in one location. However, sample analyses from Site 25 indicated that chromium is present only in the trivalent state, which is less mobile and less hazardous to human health than hexavalent chromium. The chromium RSCTL assumes the hexavalent state, and therefore is not applicable to this site. Borings where RSCTLs were exceeded occur are shown on Figure 5-1.

Contamination at Site 25 appears to be concentrated along a narrow strip approximately 100 feet long by 20 feet wide. Assuming depth of contamination is 2 feet, approximately 148 CY of soil exceed RSCTLs. The area surrounding 025-S-0009, the only outlier, is limited in extent by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SCALE FEET
NOTE:
LOCATION 025S0016 WAS
REMOVED DURING A 1998
INTERIM REMOVAL ACTION
DRAFT FEASIBILITY STUDY
OPERABLE UNIT 2
NAS PENSACOLA
PENSACOLA, FLORIDA
FIGURE 5–1
SITE 25
SOIL BORING LOCATIONS
EXCEEDING ONE OR MORE RSCTLs
DWG DATE: 04/21/99
DWG NAME: 0059G007

current buildings and pavement; the total volume represented by this location is 30 CY. 025-S-0013 is approximately 150 feet southeast of the nearest soil boring (025-S-0004), where different contaminants were identified. Therefore 025-S-0013 is assumed to be isolated and its impact is assumed to be a 100 foot by 100 foot area, to a depth of 2 feet, or a total of 740 CY.

Table 5-1
Site 25 Surface Soil Locations Exceeding RSCTLs

Location	Contaminant	Concentration (in mg/kg)
025-S-0009-00	Arsenic	2.1 J
025-S-0013-02	Benzo(a)pyrene	0.12 J
025-S-0015-00	Arsenic	4.5
	Chromium	234
	Lead	1,840
	Aroclor 1260	1.1
	Benzo(a)anthracene	2
	Benzo(a)pyrene	1.7
	Benzo(b)fluoranthene	4.7
025-S-0016-00	Arsenic	2.1
	Lead	717
	Aroclor 1260	31
	Dieldrin	0.071
	Benzo(a)pyrene	0.47
025-S-0016-01	Arsenic	1.8
	Aroclor 1260	5.7
	Benzo(a)pyrene	0.22 J
025-S-0016-02	Arsenic	0.89
025-S-0017-00	Arsenic	4.1
	Lead	904
	Mercury	3.7
	Aroclor 1254	0.91
	Aroclor 1260	0.98
	Benzo(a)anthracene	3.8 J
	Benzo(a)pyrene	3.4 J
	Benzo(b)fluoranthene	7.7 J
	Dibenz(a,h)anthracene	2.2
	Indeno(1,2,3-cd)pyrene	5.1 J

Table 5-1
Site 25 Surface Soil Locations Exceeding RSCTLs

Location	Contaminant	Concentration (in mg/kg)
025-S-0018-01	Aroclor 1260	0.78
	Benzo(a)anthracene	1.3
	Benzo(a)pyrene	0.63
	Benzo(b)fluoranthene	1.8
025-S-0019-00	Arsenic	1
025-S-0019-01	Arsenic	1.2
025-S-0019-02	Arsenic	1.1
	Aroclor 1260	0.53

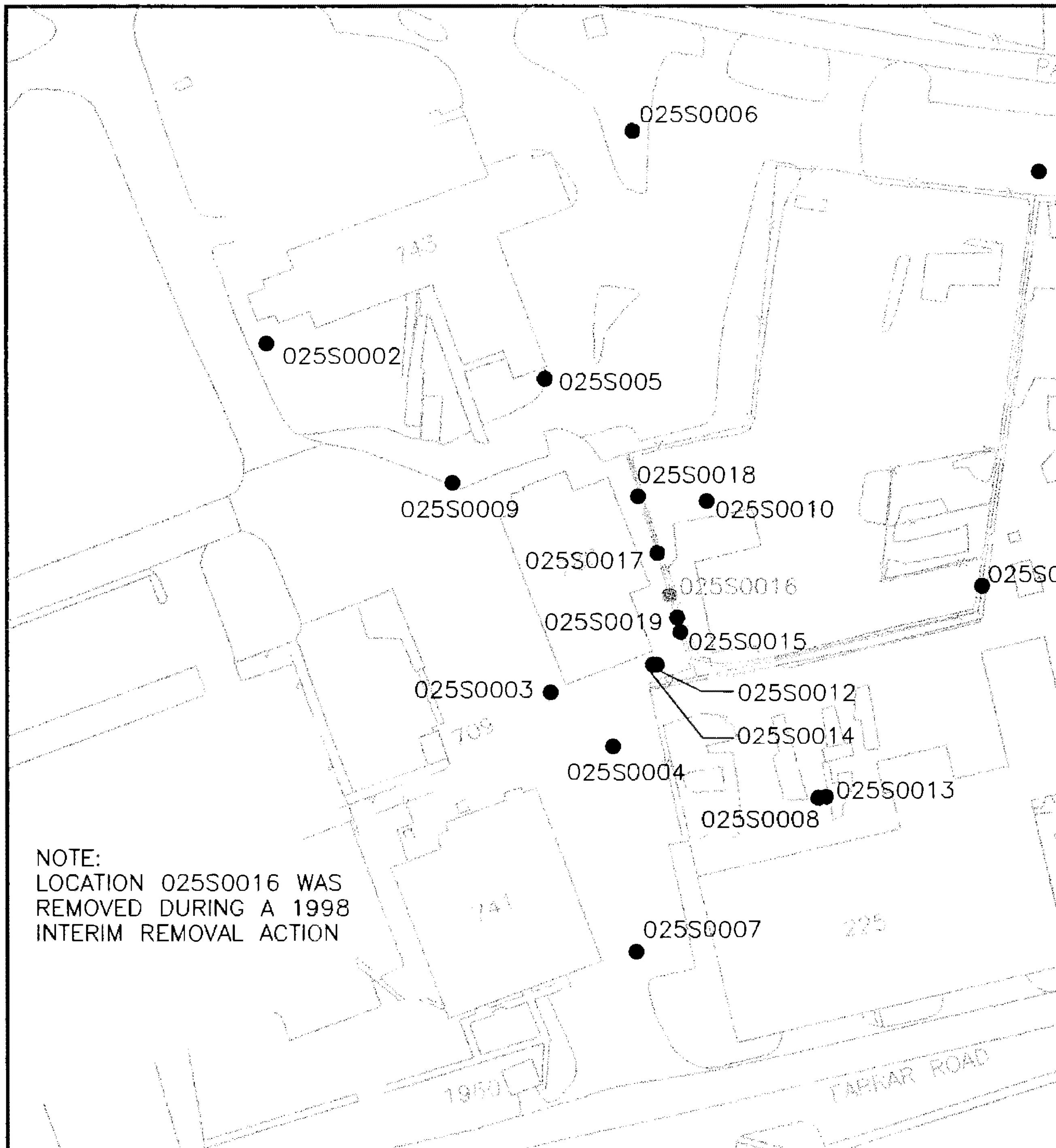
Notes:
RSCTLs may be found in Appendix C.
Soil surrounding location 025-S-0016 was excavated during the 1998 removal action.
J = Concentration is estimated
mg/kg = milligrams per kilogram

5.1.2 Site 25 Surface Soil Comparison with ISCTLs

Contaminants at four locations exceeded ISCTLs, including arsenic, lead, Aroclor 1260, and PAHs, as shown in Table 5-2. These samples are collocated along a narrow strip approximately 100 feet long by 20 feet wide, as shown in Figure 5-2. Assuming depth of contamination is 2 feet bgs, approximately 148 CY soil are present above ISCTLs.

5.1.3 Site 25 Comparison with Leaching Values Protective of Groundwater

SL-PQGs were evaluated with respect to a poor quality aquifer; exceedances are shown in Table 5-3. The exceedances detected were dieldrin in the 0- to 6-inch and 6- to 12-inch intervals at location 025-S-0016. This location was excavated during a 1998 interim removal action, therefore there are no locations that exceed leaching standards.



DRAFT FEASIBILITY STUDY
OPERABLE UNIT 2
NAS PENSACOLA
PENSACOLA, FLORIDA

FIGURE 5–2
SITE 25
SOIL BORING LOCATIONS
EXCEEDING ONE OR MORE ISCTLs

DWG DATE: 04/21/99 | DWG NAME: 0059G008

Table 5-2
Site 25 Surface Soil Locations Exceeding ISCTLs

Location	Contaminant	Concentration (in mg/kg)
025-S-0015-00	Arsenic	4.5
	Lead	1,840
	Benzo(a)pyrene	0.17
025-S-0016-00	Aroclor 1260	31
025-S-0016-01	Aroclor 1260	5.7
025-S-0017-00	Arsenic	4.1
	Benzo(a)pyrene	3.4 J
	Benzo(b)fluoranthene	7.7 J
	Dibenz(a,h)anthracene	2.2
025-S-0018-00	Benzo(a)pyrene	0.63

Notes:
ISCTLs may be found in Appendix C.
Soil surrounding location 025-S-0016 was excavated during the 1998 removal action.
J = Concentration is estimated
mg/kg = milligrams per kilogram

Table 5-3
Site 25 Locations Exceeding SL-PQGs

Location	Contaminant	Concentration (in mg/kg)
025-S-0016-00	Dieldrin	0.074
025-S-0016-01	Dieldrin	0.054 J

Notes:
SL-PQGs may be found in Appendix C.
Soil surrounding location 025-S-0016 was excavated during the 1998 removal action.
J = Concentration is estimated
mg/kg = milligrams per kilogram

5.1.4 Site 25 Comparison with Leaching Values Protective of Water Bodies

Because Site 25 does not abut any surface water bodies, comparison of soil concentrations to SL-SW criteria was not performed.

5.2 Site 25 Remedial Goals

RGs for OU 2 have been proposed for the protection of human health and the environment given current and future land use. OU 2 has historically been used for industrial purposes, as described in Section 1; future use is expected to remain the same. Future risk to human health will be minimized by maintaining OU 2 as an industrial site. Institutional controls will be required for both soil and groundwater to limit exposures above appropriate criteria.

RAOs

- Protect the health of current and future site workers. ISCTLs will be used as RGs.

- Protect the environment by ensuring future soil-to-groundwater transfers are protective of a poor quality aquifer. SL-PQG criteria will be used to determine risk to the underlying aquifer.

5.2.1 Surface Soil Remediation Goals

Surface soil RGs are based on ISCTLs; land use conditions are not expected to change. Table 5-4 presents the RGs for surface soil at OU2.

Table 5-4
Contaminant Specific Remediation Goals for Surface Soil at Site 25

Contaminant	RG (in mg/kg)
Arsenic	3.7
Lead	920
Aroclor-1260	2.1
Benzo(a)pyrene	0.5
Benzo(b)fluoranthene	4.8
Dibenz(a,h)anthracene	0.5

Notes:
mg/kg = milligrams per kilogram
RG = remedial goal

5.2.2 Subsurface Soil Remediation Goals

Based on a comparison of site analytical data with Florida SL-PQG criteria, as discussed in Section 5.1.3 and 5.1.4, contamination detected above SL-PQG and SL-SW criteria does not represent a current or potential source of groundwater contamination. Therefore, no subsurface remediation goals have been established for Site 25.

5.2.3 Soil Volumes

Table 5-5 identifies locations exceeding one or more ISCTLs. This table also identifies surface soil conditions and impacted soil volumes associated with each location.

Table 5-5
Site 25 Surface Soil Volumes Exceeding RGs

Location	Contaminant	Concentration (in mg/kg)	Comment	Soil Volume
025-S-0015-00	Arsenic Lead Benzo(a)pyrene	4.5 1,840 0.17	Exposed surface soil	45 ft by 15 ft by 2 ft. Total volume 50 CY.
025-S-0016-00	Aroclor 1260	31	Exposed surface soil	This location was removed as an interim removal action.
025-S-0016-01	Aroclor 1260	5.7	Exposed surface soil	This location was removed as an interim removal action.
025-S-0017-00	Arsenic Benzo(a)pyrene Benzo(b)fluoranthene Dibenz(a,h)anthracene	4.1 3.4 J 7.7 J 2.2	Exposed surface soil	Total soil volume for 025-S-0017, and 025-S-0018: 30 ft by 60 ft by 2 ft. Total volume 133 CY.
025-S-0018-00	Benzo(a)pyrene	0.63	Exposed surface soil	Total soil volume for 025-S-0017, and 025-S-0018: 30 ft by 15 ft by 2 ft. Total volume 133 CY.

Notes:
mg/kg = milligram per kilogram
J = Concentration is estimated
ft = foot
CY = cubic yard

The total soil volume impacted at Site 25 is approximately 180 CY. The areal distribution of contaminated media is shown in Figure 5-3.

5.3 Site 25 Soil Technologies Screening

Table 5-6 presents various remedial technologies applicable to PAHs in soil. This table evaluates each technology's applicability to Site 25, and is used to screen out technologies that are infeasible given site conditions. As discussed in Section 2, technologies have been screened for implementability, effectiveness, and cost.

The technologies retained for use at Site 25 after screening are:

- No Action, as required by the NCP.
- Institutional controls, which will be needed to maintain the industrial-use classification
- Capping
- Excavation with offsite disposal

Table 5-6 includes screening comments for each technology; the rationale for discarding other potential technologies is discussed briefly in the following paragraphs.

In situ bioremediation techniques were discarded because the mix of contaminants present at Site 25 and minimal soil volumes. Because lead, arsenic, PAHs, and PCBs are collocated, it will be technically difficult to optimize remediation that addresses all four primary contaminants. Treatment of organics only may result in a need to treat inorganics after PAH and PCB RGs are met. In addition, because PAHs are slower to degrade than other contaminants, remediation timeframes will be comparatively longer than other technologies.

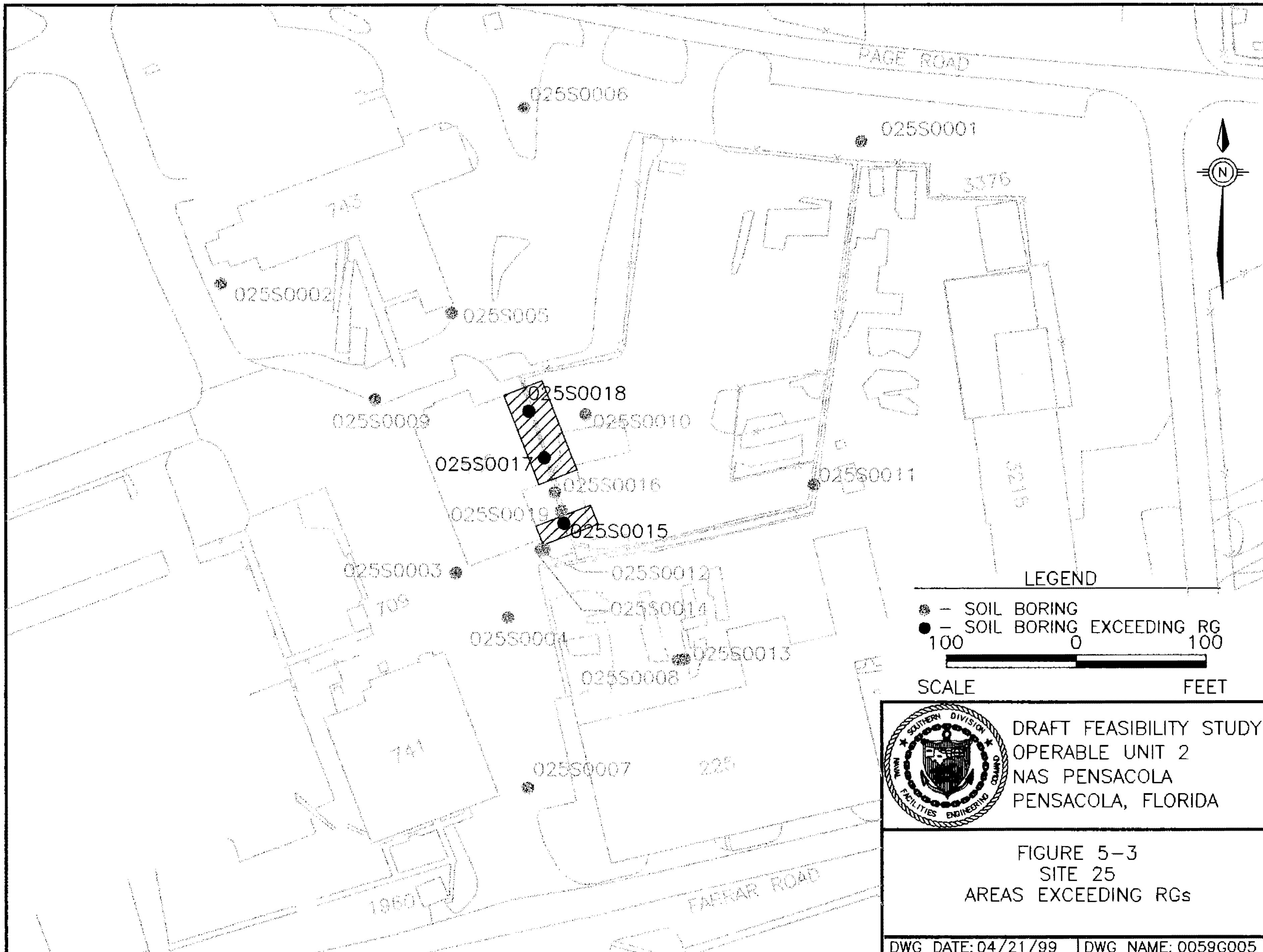


FIGURE 5-3
SITE 25
AREAS EXCEEDING RGs

Table 5-6
Soil Technology Screening — Site 25

Technology	Description	Implementability	Effectiveness	Cost
CONTAINMENT				
Surface Cap	Capping is a containment technology that will limit human contact with soil and reduce infiltration of rainwater through contaminated soil. Capping materials include soil, asphalt, and concrete.	Impacted soil is located in a narrow strip of exposed/grassy soil immediately east of Building 780. This area may be paved easily, but will require coordination with any utilities in the area.	Caps eliminate the ingestion/contact pathway, and therefore are effective at reducing risk to human health. With ongoing maintenance, the long-term effectiveness of a cap is high. Capping is an effective means of eliminating risk pathways, but it does not meet any preference for treatment, nor does it reduce contaminant toxicity, mobility, or volume.	Because this cap is intended only to eliminate a risk pathway and not to isolate waste or reduce infiltration, a multi-layer cap is not required. Costs for common capping material, such as soil, asphalt, or concrete, are comparatively low. Maintenance costs are also low.
IN SITU TREATMENT TECHNOLOGIES				
Bioremediation	Naturally occurring microbes are stimulated by amending contaminated soils to enhance biodegradation. Nutrients, oxygen, hydrogen peroxide, and other amendments may enhance biodegradation and contaminant desorption from subsurface materials. Amendments may be added through solution (such as water), or they may be mixed into the soil using tillers or rippers. When mechanical mixing is required, such as with in situ land farming applications, in situ bioremediation effectiveness is limited at depth. Similarly, effectiveness may be limited if deeper zones exhibit preferential pathways and nutrient/amendment delivery is irregular. Bioremediation may occur in aerobic and anaerobic conditions. In some cases, commercially obtained microbes may be used to supplement native populations.	Bioremediation may be technically implementable at Site 25; contamination is limited to the top 2 feet, and thus may easily be controlled. There appears to be adequate space around the impacted area to facilitate an in situ remedy.	Bioremediation's effectiveness at Site 25 is questionable, given the broad range of contaminants identified. Effectiveness is likely improved due to shallow contaminant conditions, and the porous nature of the impacted media may facilitate uniform amendment delivery. However, bioremediation is not effective in treating lead and arsenic, both of which are present in Site 25 soil.. Degradation of PAH compounds is typically slower than more amenable compounds, such as BTEX; PCBs are typically regarded as recalcitrant. If lead concentrations are high, biological activity may be impaired. Bioremediation is considered a destructive technology.	Bioremediation costs are typically variable because the need for amendments is highly site specific. However, in situ bioremediation costs are typically lower than other in situ technologies such as SVE. This option is not likely to be cost effective given the small volume of contaminated soil at Site 25.

Table 5-6
Soil Technology Screening — Site 25

Technology	Description	Implementability	Effectiveness	Cost
IN SITU TREATMENT TECHNOLOGIES (continued)				
Bioventing	Air is either extracted from or injected into the unsaturated soils to increase oxygen concentrations and stimulate biological activity. Bioventing is applicable for any contaminant that more readily degrades aerobically than anaerobically. This process is used to deliver amendments to zones deeper than what can be managed by bioremediation practices alone. Flow rates are much lower than soil vapor extraction, minimizing volatilization and release of contaminants to the atmosphere. Where preferential pathways exist in the vadose zone, air flow may not reach all contaminated media.	Bioventing is not technically implementable to Site 25, given that contamination is limited to the 0- to 2-foot interval.	Bioventing is unlikely to be more effective than natural degradation processes at this site, given that surface soil is already highly oxygenated. Bioventing is likely not effective at removing PCBs, and has no effect on inorganics. Bioventing enhances biodegradation, and therefore is considered a destructive technology.	Bioventing is relatively inexpensive, though ongoing use of blowers and ancillary piping will require O&M. This option is not likely to be cost effective given the small volume of contaminated soil at Site 25.

Table 5-6
Soil Technology Screening — Site 25

Technology	Description	Implementability	Effectiveness	Cost
IN SITU TREATMENT TECHNOLOGIES (continued)				
Phytoremediation	Phytoremediation is the use of plants to remove, contain, and/or degrade contaminants. Examples include: enhanced rhizosphere biodegradation, phytoaccumulation, phytodegradation, and phytostabilization. Climatic or hydrologic conditions may restrict the rate of growth of the remediation plants.	Phytoremediation may be technically implementable at Site 25; contamination is limited to the top 2 feet, and thus there are likely a wide variety of plants which may be used to remediate site soil. Implementation of phytoremediation will require identifying a plant or plants amenable to all site compounds (arsenic, lead, PAHs, and PCBs), and optimizing growing conditions. Because remediation time frames may be long, plans for future site use may be impacted by phytoremediation.	Phytoremediation is an innovative technology that may be effective at Site 25 given that contamination is limited to the top 2 feet, well within the root zones of some plants. Shallow contamination is easily monitored and controlled. Although high concentrations of hazardous materials can be toxic to plants, contaminant concentrations at Site 25 are not excessive (e.g., percent levels). The range of contaminants present in Site 25 soil, however, may limit overall effectiveness of this technology. Phytoremediation may be a destructive remediation technology, depending on the type of plants used. It may also be used as a containment or immobilization strategy, binding contaminants in soil or biomass. However, there is concern that phytoremediation is reversible. Additionally, plants that have died or which are removed from the site may require special management or handling due to concentrated contaminants within the biomass.	Costs for phytoremediation are expected to be low compared with other in situ techniques. Maintenance costs are also expected to be relatively low, consisting of monitoring and watering costs. This option is not likely to be cost effective given the small volume of contaminated soil at Site 25.

Table 5-6
Soil Technology Screening — Site 25

Technology	Description	Implementability	Effectiveness	Cost
IN SITU TREATMENT TECHNOLOGIES (continued)				
In Situ Solidification/ Stabilization	In situ stabilization immobilizes contaminants by mixing site soil with portland cement, lime, or a chemical reagent to reduce the mobility of the contaminant. Large augering equipment is used to mix soils in place with the reagent. This technology will likely leave a solid mass (similar to concrete) onsite.	This technology is technically implementable at Site 25. Contaminated soil is limited to the 0- to 2-foot interval, which is easily mixed. The stabilized mass may be left in place, and use of the area for parking and access may continue.	Solidification/stabilization is an effective technology for immobilizing lead and arsenic. It can be an effective containment strategy for PAH and PCB compounds. Some organic-contaminated soils may delay or inhibit reactions necessary for solidification. Long-term, the stabilized mass can degrade, particularly if subject to repeated abuse. Solidification/stabilization is not a permanent treatment technology and does not remove or destroy contaminants; rather, contaminants are immobilized. Treated media typically must be managed long term (e.g., through institutional controls and monitoring).	Solidification/stabilization costs typically vary given the stabilizing material required (e.g., fly ash, portland cement, etc.). However, these costs are typically low compared with destructive in situ options. This option is not likely to be cost effective given the small volume of contaminated soil at Site 25.
EX SITU TREATMENT TECHNOLOGIES				
Solid-phase biodegradation. • Biopiles • White rot fungus • Landfarming	Excavated soils are mixed with amendments, nutrients, enzymes, or fillers and placed in aboveground enclosures. Mixing may be required, as in a traditional landfarming application. Conversely, biopiles may be used simply to deliver oxygen uniformly throughout a large pile. Ex situ biological systems may be designed to degrade specific compounds and maintain specified degradation conditions (aerobic vs. anaerobic). Mechanical mixing, such as tilling or turning of windrows, may be required.	Although technically implementable, the small volume of contaminated soil present at Site 25 may limit the administrative implementability of this technology. Space is available immediately east of Building 780 for construction of solid phase ex situ bioremediation units.	Ex situ bioremediation systems may be tailored to the specific contaminant requiring treatment. Biodegradation is typically limited to organic compounds, and heavy metals may be toxic to microorganisms. Remediation half-lives for PAHs may be slower than more degradable compounds, such as BTEX, which may extend the remediation time frame. The mix of contaminants present in Site 25 soil, particularly PCBs, may complicate remediation and reduce the overall effectiveness. Solid phase bioremediation is a permanent , destructive technology.	Ex situ solid phase bioremediation is inexpensive compared with other ex situ techniques. However, given the need to design specific nutrient amendments and process control systems, more recalcitrant organics are typically more expensive to treat. This option is not likely to be cost effective given the small volume of contaminated soil at Site 25.

Table 5-6
Soil Technology Screening — Site 25

Technology	Description	Implementability	Effectiveness	Cost
EX SITU TREATMENT TECHNOLOGIES (continued)				
Slurry Phase Biological Treatment	Slurry-phase bioreactors containing co-metabolites and specially adapted microorganisms can be used to treat halogenated VOCs and SVOCs, pesticides, and PCBs. An aqueous slurry is created by combining soil with water and other additives. The slurry is mixed continuously to keep solids suspended and microorganisms in contact with the soil contaminants. Upon completion of the process, the slurry is dewatered and the treated soil is disposed of.	Although technically implementable, the small volume of contaminated soil present at Site 25 may limit the administrative implementability of this technology. Existing structures and utilities may impede or restrict excavation. Space is available immediately east of Building 780 for construction of slurry-phase bioreactors.	Slurry-phase bioreactors are used primarily to treat nonhalogenated SVOCs and VOCs in excavated soils or dredged sediments. Ex situ bioremediation systems may be tailored to the specific contaminant requiring treatment. Biodegradation is typically limited to organic compounds, and heavy metals may be toxic to microorganisms. Remediation half-lives for PAHs and PCBs may be slower than more degradable compounds, such as BTEX, which may extend the remediation time frame. Slurry phase bioremediation is a permanent, destructive technology.	Ex situ slurry phase bioremediation is expensive compared with other biological techniques, due to the controls and materials handling required. This option is not likely to be cost effective given the small volume of contaminated soil at Site 25.

Table 5-6
Soil Technology Screening — Site 25

Technology	Description	Implementability	Effectiveness	Cost
EX SITU TREATMENT TECHNOLOGIES (continued)				
Soil Washing • Chemical Extraction • Acid Extraction • Solvent Extraction • Separation Techniques	Excavated soil is washed with aqueous-based solutions to separate contaminants sorbed onto fine particles from the rest of the soil matrix. The fractions of soil to be treated are processed in a slurry with specific leachant mixtures to ionize target metals. The solvent/waste mixture is then treated further to develop a concentrated leaching solution. which may be treated or disposed off offsite. Traditional soil washing options may also include separation techniques which concentrate contaminated solids through physical and chemical means. These processes seek to detach contaminants from their medium (e.g., soil, sand, or other binding material). Gravity separation, magnetic separation, and sieving/physical separation are examples of this technology.	Although technically implementable, the small volume of contaminated soil present at Site 25 may limit the administrative implementability of this technology. Soil washing systems will require operational space as well as possible water and sewer connections; space is available immediately east of the contaminated area near Building 780.	Overall, this technology is effective at removing SVOCs and inorganics. It is less effective at treating VOCs. In general, acid extraction techniques are suitable for treating soils contaminated by heavy metals. Solvent extraction has been shown to be effective in treating soils containing primarily organic contaminants, but is generally least effective on very high molecular-weight organic and very hydrophilic substances. Soils with higher clay content may reduce extraction efficiency and require longer contact times. High humic content in soil may require pretreatment. It may be difficult to remove organics adsorbed to clay-size particles. These adverse soil conditions are not expected at Site 25. Soil washing is a permanent treatment technology which removes contaminants from soil to another medium (e.g., solvent, carbon, etc.). Treatment residuals then may require treatment or disposal Soil washing solvents may also pose environmental risks.	Soil washing is typically an expensive remediation alternative because of the highly site-specific design requirements and the need to treat and/or dispose of the leaching solvent. Magnetic separation is specifically used on heavy metals, radionuclides, and magnetic radioactive particles, such as uranium and plutonium compounds. This option is not likely to be cost effective given the small volume of contaminated soil at Site 25.

Table 5-6
Soil Technology Screening — Site 25

Technology	Description	Implementability	Effectiveness	Cost
		EX SITU TREATMENT TECHNOLOGIES		
Chemical/ Physical Oxidation • permanganate flooding • Fenton's reagent • Wet air oxidation • Supercritical water oxidation	Chemical oxidation is a process in which the oxidation state of a contaminant is increased while the oxidation state of the reactant is decreased. The reactant can be another element, including the oxygen molecule, or it may be a chemical species containing oxygen, such as hydrogen peroxide or chlorine dioxide. In the case of physical oxidation technologies, wet air oxidation and supercritical water oxidation both use high pressure and temperature to treat organic contaminants.	Chemical oxidation is not technically implementable at Site 25, given the low soil volumes. Iron and manganese in the soil will compete with contaminants for oxygen.	This technology is effective in treating media contaminated with halogenated and non-halogenated volatiles and semivolatiles, PCBs, pesticides, cyanides, and volatile and nonvolatile metals. Wet air oxidation can treat hydrocarbons and other organic compounds. Supercritical water oxidation is applicable for PCBs and other stable compounds. Oxidation is a permanent treatment technology, in which contaminants are destroyed.	Costs for chemical oxidation processes may be comparable to soil washing costs, given the need to construct and operate ex situ reactors, and the need to control reagents and reactor conditions. Costs may vary widely with the type of oxidation technique implemented. The small soil volumes at Site 25 likely render this technology cost-prohibitive.
Ex Situ Solidification/ Stabilization	Contaminants are physically bound or encased within a stabilized mass, or chemical reactions are induced with stabilizing agents. The contaminants are not removed or destroyed, but their mobility is reduced. Examples of S/S technologies include: bituminization, emulsified asphalt, modified sulfur cement, polyethylene extrusion, pozzolan/portland cement, radioactive waste solidification, sludge stabilization, and soluble phosphates.	Ex situ stabilization/ solidification is the best-demonstrated technology for multiple compounds. It is technically implementable, and often required to render contaminants non-hazardous before offsite disposal. Site contaminants are non-hazardous PAHs and PCBs, and it is unlikely that it will be necessary to render these concentrations lower to meet treatment standards.	This technology works well for inorganics such as arsenic and lead present at Site 25. Although organic- contaminated soil may be treated with solidification/stabilization, some organics can delay or inhibit reactions necessary for solidification. Solidification/ stabilization is not a permanent treatment technology and does not remove or destroy contaminants; rather, contaminants are immobilized. Treated media typically must be managed appropriately, i.e., landfilled or contained onsite. Where used as asphalt or similar covers, degradation due to normal asphalt weathering should be considered.	Solidification/stabilization costs typically vary given the stabilizing material required (e.g., fly ash, portland cement, etc.). However, ex situ stabilization/ solidification is inexpensive, compared with other ex situ technologies. This option is not likely to be cost effective given the small volume of contaminated soil at Site 25.

Table 5-6
Soil Technology Screening — Site 25

Technology	Description	Implementability	Effectiveness	Cost
EX SITU TREATMENT TECHNOLOGIES				
Incineration/ Pyrolysis	Incineration burns contaminated sediment at high temperatures (1,600° - 2,200°F) to volatilize and combust organic contaminants. A combustion gas treatment system must be included with the incinerator. The circulating bed combustor, fluidized bed reactor, infrared combustor, and rotary kiln are several types of incinerators. Pyrolysis is chemically changes contaminated sediment by heating it in the absence of air. Pyrolysis can be achieved by limiting oxygen to rotary kilns and fluidized bed reactors. Molten salt destruction is another example of pyrolysis.	Incineration/ pyrolysis is not technically implementable at Site 25, given that soil volumes are very low – likely inadequate for a trial burn. The lead agency will likely be reluctant to construct an incineration unit for a small-volume, short-term project. Administrative implementability will be limited by the need for submitting documentation and testing the unit's compliance with ARARs. Highly abrasive feed can damage the processor unit. The technology requires drying the soil to achieve less than 1% moisture content.	Incineration may be effective in treating organic-contaminated soil, but not for soil with metals as the primary contaminants. The target contaminant groups for pyrolysis are SVOCs and pesticides. Pyrolysis is not effective in either destroying or physically separating inorganics from the contaminated medium. Volatile metals may be removed by the higher temperatures, but are not destroyed. Incineration is a permanent treatment technology; COCs are destroyed during treatment.	Incineration/ pyrolysis are typically very expensive remedial options compared with other ex situ remediation. The small soil volumes at Site 25 likely render this technology cost prohibitive.
Thermal Desorption	Soil is generally heated between 200° and 1,000°F to separate VOCs, water, and some SVOCs from the solids into a gas stream. The organics in the gas stream must be treated or captured. Thermal desorption may be used at high or low temperatures depending on the volatility of the contaminants.	Thermal desorption is technically implementable at Site 25. Some thermal desorbers may be regulated as incinerators, depending on construction. Testing and optimization would be required. Administrative implementability will likely be limited given current and future site use. Highly abrasive feed can damage the processor unit. Although clay and silty soils and soil with high humic content increase reaction time due to binding of contaminants, this problem would not be anticipated for Site 25.	Thermal desorption units are effective at removing primarily organic contaminants. Residence time and temperature inside the unit can be varied to volatilize recalcitrant organics. Inorganic contaminants or metals that are not particularly volatile will not be effectively removed by thermal desorption. Vapor phase organics must be concentrated and treated or otherwise disposed of. Thermal desorption is a permanent treatment technology which will eliminate risk by removing COCs from site soil.	Although less expensive than other ex situ thermal treatment methods, thermal desorption is still comparatively expensive. Costs increase with the degree of materials handling, pre-and post- treatment, and off-gas controls required. The small soil volumes at Site 25 likely render this technology cost prohibitive.

Table 5-6
Soil Technology Screening — Site 25

Technology	Description	Implementability	Effectiveness	Cost
Excavation and Offsite Disposal	Contaminated soil is excavated and disposed of offsite at a licensed waste disposal facility.	Excavation with offsite disposal is both technically and administratively implementable at Site 25. Contaminated media can be removed and disposed offsite. The excavated areas can then be backfilled with clean fill with minimal impact to operations at adjacent buildings. Testing will be required before the soil is disposed of; TCLP results may impact disposal options. Transporting the soil through populated areas may affect community acceptance; however, given the small volumes anticipated at Site 25, this is not expected to be an issue.	Excavation with offsite disposal is expected to be an effective remediation option. It is effective for all contaminants because the risk pathway is eliminated. This is a permanent remedial technology.	Costs for excavation and offsite disposal vary, depending on whether waste is classified as hazardous. However, compared with other options (including treatment or disposal at an incineration facility), landfilling is relatively less expensive.

Similarly, in situ and ex situ solidification/stabilization were discarded as possible technologies because of adjacent land use and projected soil volumes. Solidification/stabilization is primarily used to minimize leaching and contaminant mobility, which are not a problematic for PAHs and PCBs, the primary constituents in site soil. Mobilizing solidification/stabilization contractor to the site for approximately 180 CY of soil likely be more expensive than other implementable soil technologies.

Ex situ reactor-based treatment, such as solid and slurry phase biodegradation, soil washing, and chemical oxidation were also eliminated based on the small volume of soil requiring treatment. Each of these technologies requires construction of infrastructure, which may range from haybales and polyethylene liners for a small landfarming unit, to mixers and contact chambers for a soil washing unit. Once again, the construction of treatment units for such a small volume of soil is likely to be cost-prohibitive.

Thermal treatments, such as incineration, pyrolysis, and thermal desorption, although effective for organic compounds, were discarded because of the high costs and implementation obstacles associated with meeting ARARs. If thermal treatment is identified at another site as a viable option, consolidation might be considered. However, contamination across OU 2 is significantly low enough that other treatment options will likely meet the statutory preference for treatment.

5.4 Site 25 Soil Alternatives

The following alternatives have been retained for Site 25 soil.

- Alternative 1: No Action
- Alternative 2: Institutional controls
- Alternative 3: Asphalt Cap
- Alternative 4: Excavation with Offsite Disposal

5.4.1 Alternative 1: No Action

Under this alternative, no changes would be made to existing site operations or exposure scenarios. While the current and projected land use for this site is expected to remain institutional, there are no institutional controls to guarantee the exposure pathway would remain industrial. Without controls, a residential scenario must be assumed in which all existing pavement and buildings are removed.

Implementability

The no-action alternative could be easily implemented. The Navy would be required to perform a 5-year review to assess adequacy of the alternative.

Effectiveness

The no-action alternative is not effective at protecting human health, as contaminants above residential and industrial SCTLs are left onsite. As discussed in the BRA, if residential exposures occur Site 25 soil presents a combined soil ingestion/contact pathway risk of 1E-04 to potential future site residents; this risk is at the upper end of the allowable range cited in the NCP (1E-06 to 1E-04), and exceeds the FDEP threshold criteria of 1E-06.

Cost

Table 5-7 presents the costs associated with the no-action alternative.

5.4.2 Alternative 2: Institutional Controls

No remedial actions will be implemented under this alternative. LUCAs would be implemented to limit access and property use to industrial/commercial, thereby limiting unacceptable exposure to contamination.

Table 5-7
Alternative 1 — Costs for No Action

Action	Quantity	Cost per Unit	Total Cost
Five Year Review	LS	$10,000	$10,000
Present value subtotal at 6% discount over 30 years			$24,400
Total Cost			**$24,400**

Notes:
LS = lump sum
Cost based on review once every five years for 30 years.

This alternative does not require any changes to existing activities, since current land use at Site 25 is industrial. However, controls would be required to minimize exposures which could include maintenance activities in impacted areas. Notification of the Base Environmental office would be required to ensure proper instruction before invasive activities begin.

Implementability

Implementation of this alternative does not require any innovative technologies or construction activities; ongoing operations would not be interrupted. This alternative would require the Navy to control site access to the property and to keep its use industrial/commercial. Site access can be controlled through the LUCA and/or warnings against excavation. The site would be inspected annually to ensure compliance with the LUCA. If the property was no longer under direct Navy control, development of a deed restriction would be necessary. The Navy has base planners and attorneys on staff with experience to develop and implement proper institutional controls for Site 25. The possibility of transferring Site 25 to civilian control is highly unlikely in the near future; therefore, proper controls can be implemented through planning.

The NCP requires any alternative which leaves contamination onsite to be reevaluated ever 5 years to ensure its adequacy. Therefore, the institutional controls alternative would require the Navy to establish a monitoring program.

Effectiveness

Institutional controls at Site 25 would limit unacceptable exposure to surface soil contamination. Under current site conditions, surface soil exceeds ISCTLs at three sample locations. This alternative would not provide any additional effectiveness for the current use scenario, but would provide long-term effectiveness by restricting future use and access. This alternative still poses some risk to site workers, because three locations exceeding the ISCTLs for PAHs will remain. However, workers would be exposed only during activities in which they contact surface soil. No risks are posed during implementation of institutional controls.

In addition, this alternative ensures that intrusive activities are not permitted near the impacted area where concentrations exceeded ISCTLs.

This alternative does not provide more protection to site workers than the current scenario, but it does eliminate the future resident exposure pathway by excluding the property from residential use. Likely exposures will be less than the worst case assumed in SCTL development (*Technical Report: Development of Soil Cleanup Target Levels*, ERC Hearing Draft, May 1999).

As demonstrated in the BRA, Site 25 meets the NCP's allowable risk range of1E-06 to 1E-04 for the industrial scenario, with a combined ingestion/contact pathway risk of 1.8E-05 for future site workers; however this exceeds FDEP's risk threshold of 1E-06.

Cost

The total present-worth cost of the institutional controls alternative is estimated at $74,400. As shown in Table 5-8, the Navy assumes implementation of institutional controls will cost approximately $50,000, which is the estimated cost for completing the necessary documentation and annual review of site use. In addition a 5 year reevaluation of site conditions will be required for 30 years, as per the NCP. The estimated cost for each reevaluation is $10,000 per event; assuming a 6% discount rate over 30 years, the present worth of reevaluation requirements is approximately $24,400.

Table 5-8
Alternative 2 — Costs for Institutional Controls

Action	Quantity	Cost per Unit	Total Cost
Five Year Review	LS	$10,000	$10,000
Present value subtotal at 6% discount over 30 years			$24,400
Institutional Controls (LUCA and Signs)	LS	$50,000	$50,000
Total Cost			$74,400

Notes:
LS = lump sum
Cost based on review once every five years for 30 years.

5.4.3 Alternative 3: Asphalt Cover

Installing an asphalt cover would reduce the risk of site workers contacting areas of exposed contaminated soil, thus eliminating exposure pathways. Institutional controls would also be incorporated to restrict future access to contaminated soil. Limited excavation would eliminate risk from isolated areas of contaminated soil.

Remedial activities for the asphalt cover would consist of:

- Implementing institutional controls (LUCA)
- Confirmatory sampling
- Site preparation
- Cover placement

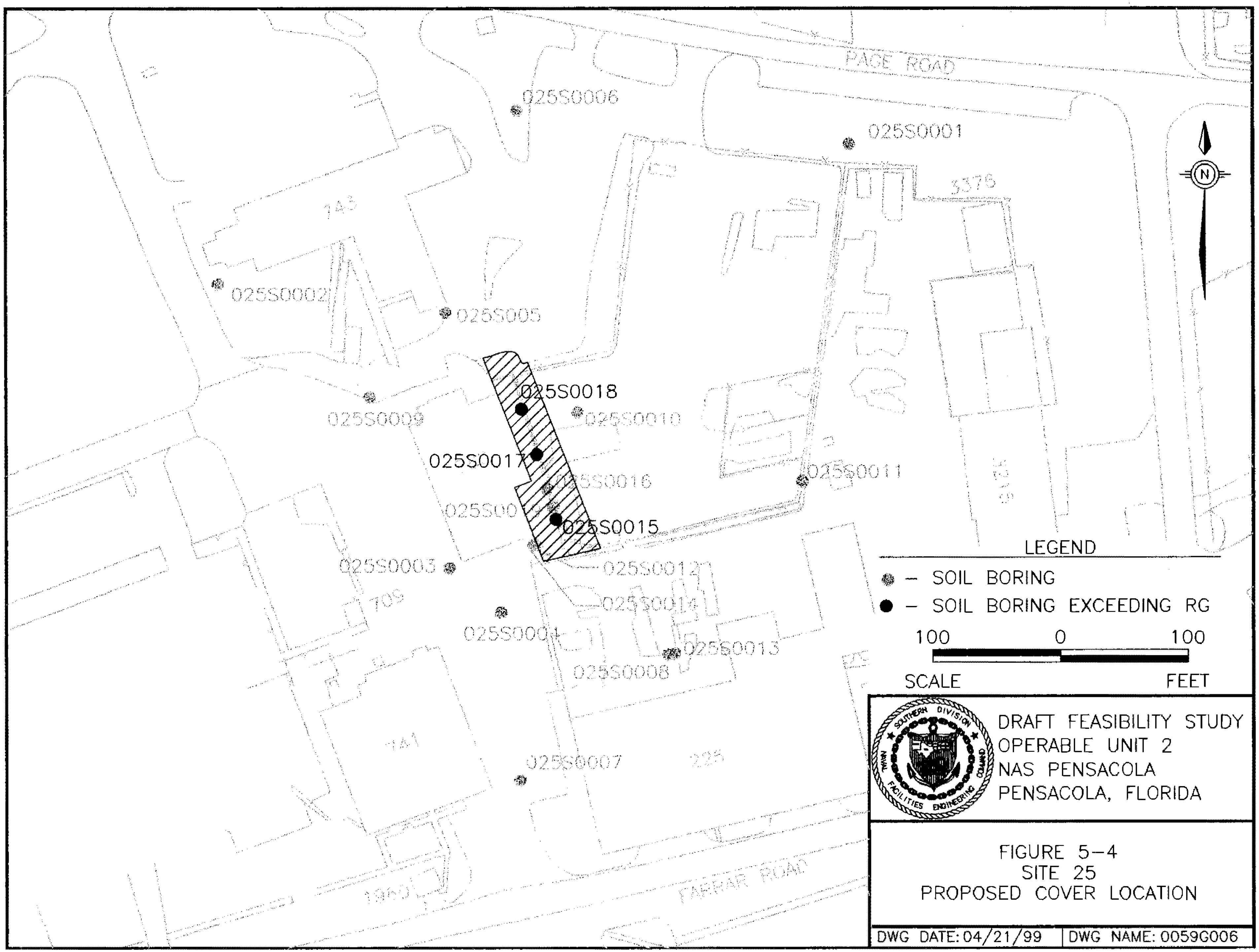
Cover construction would consist of a 4- to 8- inch asphalt pavement placed over the contaminated soil areas. The pavement would be sloped to direct runoff toward open or grassy areas where percolation may occur. Confirmation sampling would help delineate the extent of soil in which contaminant concentrations exceed RGs to ensure that all contaminated soil is covered.

Implementability

Cover construction with institutional controls is technically feasible at Site 25. The site is suitable for asphalt or concrete covering to protect site workers from contaminated soil and to control runoff. Land use restrictions may be used to implement institutional controls. The Site 25 area that would be covered are shown in Figure 5-4; the total area to be covered is approximately 8,000 square feet (ft^2). Actual areas to be covered would be determined in the field following confirmation sampling.

Effectiveness

Covers provide reliable protection against dermal contact and ingestion of contaminated soil. They isolate contaminants exceeding risk and guidance concentrations in environmental media, but are not designed to manage solid or hazardous waste. Confirmation sampling will ensure the entire area exceeding RGs is covered. Once the cover is in place, institutional controls would help ensure continued cover effectiveness and regular maintenance would be required.



DRAFT FEASIBILITY STUDY
OPERABLE UNIT 2
NAS PENSACOLA
PENSACOLA, FLORIDA

FIGURE 5–4
SITE 25
PROPOSED COVER LOCATION

DWG DATE: 04/21/99 | DWG NAME: 0059G006

Cost

Table 5-9 presents the capital costs associated with installation of an asphalt cover and institutional controls.

Table 5-9
Alternative 3 — Costs for Asphalt Cover

Action	Quantity	Cost per Unit	Total Cost
Capital Costs for Asphalt Cover			
Mobilization/Demobilization	LS	$500	$500
Grading/site preparation	890 yd²	$1.50/yd²	$1,340
Asphalt/Concrete Surface (8" depth)	8,000 ft²	$1.76/ft²	$14,080
Engineering/Oversight	LS	20% cost	$3,180
Contingency/Miscellaneous	LS	25% cost	$3,980
Subtotal			$23,080
Operation and Maintenance Cost			
Maintain cover (30 years)	890 yd²	$2/yd²	$1,780
Inspection	LS	$500	$500
Subtotal			$2,280
Present value at 6% discount over 30 years			$31,380
Confirmation Sampling	4 samples (plus 2 QA/QC samples)	$500/sample	$2,500 *
Institutional Controls (LUCA and signs)		LS	$50,000
Subtotal			$52,500
Remedial Contractor Cost			$100,000
Total Cost			$207,960

Note:
LS = Lump sum
yd² = square yard
* = Assumes one sample will be collected along each edge of the contaminated area. Samples will be analyzed for SVOCs and pesticides/PCBs.

5.4.4 Alternative 4: Excavation with Offsite Disposal

This alternative involves excavating surface soil in which contaminants exceed compound-specific RGs and disposing of it offsite. Approximately 180 yd^3 of surface soil would be removed from the site to eliminate threats to current or future industrial site workers through dermal contact and ingestion exposure pathways. Since soil removal is based on meeting ISCTLs, institutional controls (the LUCA) will be used to ensure that future use remains industrial. Proposed removal areas are shown in Figure 5-4.

Because contaminant concentrations are relatively low and concentrations are inconsistent from boring to boring, Site 25 soil is not expected to be considered hazardous waste. Remedial activities would consist of:

- Implement institutional controls (LUCA)
- Excavation
- Confirmatory sampling
- Backfill
- Transport of excavated material offsite
- Landfill at a Subtitle D facility

Confirmation samples would be collected from surface soil surrounding the excavation to ensure complete removal of soil in which contaminant concentrations exceed RGs.

After the contaminated soil is removed, clean backfill would be placed in the excavated areas and graded. TCLP analysis would be conducted to determine if the excavated soil exhibits toxicity characteristics.

Implementability

This alternative is both technically and administratively feasible at Site 25. Excavation is performed frequently and is a reliable method to remove contaminated soil within given boundaries. No technology-specific regulations apply to excavation and offsite disposal (i.e., landfilling) alternatives. Except for implementing land use restrictions, no long-term maintenance or monitoring would be required after soil in which contaminant concentrations exceed RGs has been removed. Based on groundwater elevation data presented in the RI report, groundwater is not expected to pose a problem during excavation.

Administrative considerations would include:

- Transportation and disposal of contaminated soil must adhere to USDOT regulations and requirements.

- Scheduling would be required to reduce costs for roll-off boxes and downtime while transporting the soil from Site 25 to the disposal facility.

- Daily operations at the surrounding activities will likely be interrupted on a short-term basis by access problems during the removal process.

No capacity limitations are expected at the landfill, given low projected soil volumes.

Effectiveness

Excavation with offsite disposal would protect the environment at Site 25 by reducing the amount of soil in which contaminant concentrations exceed RGs onsite.

Short-term inhalation, ingestion, and contact risks to site workers (excavation crew) would temporarily increase during excavation but should last only until remedial actions are complete.

Onsite actions will require health and safety practices consistent with PAH contamination and dust generation. These risks will be reduced through proper use of PPE and engineering controls. Because no residential areas are adjacent to Site 25, there are no short-term risks to the surrounding community. No onsite long-term risks are associated with this alternative because exposed soil in which contaminants exceed the FDEP ISCTL would be removed.

The excavation alternative is particularly applicable to Site 25 soil because of the mixture of contaminants present. Treatment can be streamlined when there are one or two similar compounds to treat, but the combination of PAHs, PCBs, and inorganics complicate remedial efforts.

Cost

Table 5-10 presents the capital costs associated with excavation and offsite disposal at a Subtitle D facility.

Table 5-10
Alternative 4 — Costs for Excavation and Offsite Disposal

Action	Quantity	Cost per Unit	Total Cost
Excavation	180 CY	$20/CY	3610
Confirmation Sampling	10 samples (plus 3 QA/QC samples)	$250/sample	2500 [a]
Backfill	230 CY	$15/CY	3450 [b]
Subtotal			$9,560
Subtitle D Disposal Facility			
Transportation	12 trucks (assuming 20 yd^3 each) hauling 30 miles	$3.50/loaded mile	$1260 [b]
Soil Disposal	270 tons	$36/ton	$9720 [c]
Engineering/Oversight	LS	20% cost	$2,200
Contingency/Miscellaneous	LS	25% cost	$2,750
Subtotal			$15,930

Table 5-10
Alternative 4 — Costs for Excavation and Offsite Disposal

Action	Quantity	Cost per Unit	Total Cost
Institutional Controls (LUCA and signs)			\$50,000
Remedial Contractor Cost			\$100,000
Total			\$175,490

Notes:
LS = lump sum
[a] = Samples include one from each side of the two excavations, and one from each base.
[b] = Assumes 30% fluff after excavation.
[c] = Assumes 1.5 tons per cubic yard.

5.5 Evaluation of Soil Alternatives

The following alternatives have been retained for Site 25 soil:

Soil Alternatives

Alternative 1: No Action

Alternative 2: Institutional Controls

Alternative 3: Asphalt Cover

Alternative 4: Excavation and Offsite Disposal

Each alternative is evaluated according to the nine criteria discussed in Section 2. Criteria have been divided into the three categories — threshold, balancing, and modifying.

5.5.1 Alternative 1: No Action

The no-action alternative for Site 25 involves no active remedial effort. No actions will be taken to contain, remove, or treat soil contamination above RGs. Soil will remain in place. No engineering or institutional controls will be implemented. The no-action alternative provides a baseline against which other alternatives can be compared.

No Action: Threshold Criteria

Overall Protection of Human Health and the Environment: The no-action alternative provides no additional protection of human health and the environment. This alternative assumes that future use is residential. Site 25 soil exceeds RSCTLs at seven locations. These exceedances would remain onsite, unmitigated. Under an uncontrolled use scenario, the BRA calculated site risks to be 1.0E-4 (residential exposure).

Compliance with ARARs: Alternative 1 does not comply with the RGs developed for Site 25; moreover, contaminants will pose risk under an uncontrolled future use scenario. Florida Proposed Rule 62-777 is a potential ARAR for OU 2. No location- or action-specific ARARs are triggered by the No Action alternative.

No Action: Balancing Criteria

The primary balancing criteria are the technical criteria on which the detailed analysis is based.

Long-term Effectiveness and Permanence: Long-term effectiveness of Alternative 1 is minimal. Soil volumes and concentrations would remain unchanged. In addition, this alternative does not reduce the magnitude of residual risk and lacks treatment actions that would provide permanence.

Any controls currently in place at the site — military security and limited access to/use of the site — would remain. If use were unrestricted, no controls would be in place to protect potential receptor groups (i.e., residents).

Reduction of Toxicity, Mobility, or Volume Through Treatment: This alternative would not reduce soil contaminant mobility, toxicity, or volume. Contaminants would remain untreated and in place.

Short-Term Effectiveness: Short-term effectiveness assesses an alternative's effect on human health and the environment while it is being implemented. There are no such effects from the no-action alternative

Implementability: The no-action alternative is technically feasible and easily implemented. No construction, operation, or reliability issues are associated with this alternative. Current access controls — including military security and limited personnel access to the site — have historically been reliable. No administrative coordination, offsite services, materials, specialists, or innovative technologies are required. There are no implementation risks associated with Alternative 1.

Cost: Costs include a site review and report preparation every five years for 30 years. Each review and report are estimated to cost $10,000, with a present-worth of $24,400 for the 30-year period.

No Action: Modifying Criteria

The modifying criteria are assessed formally after the public-comment period. However, the criteria are factored into identifying the preferred alternatives, as far as they are known.

State/Support Agency Acceptance: FDEP and the USEPA will have the opportunity to review and comment on this FS.

Community Acceptance: These criteria are generally not completed until after public comments on the RI/FS report and the proposed plan are received.

5.5.2 Alternative 2: Institutional Controls

The institutional controls alternative for Site 25 involves no active remedial effort. No actions will be taken to contain, remove, or treat soil contamination that above RGs. Soil would remain in place and institutional controls would be incorporated into the LUCA to ensure Site 25 remains an industrial use area.

Institutional Controls: Threshold Criteria

Overall Protection of Human Health and the Environment: The institutional controls alternative provides additional protection of human health and the environment by reducing the potential for uncontrolled site access. By restricting use to industrial/commercial, future risks from residential ingestion of or contact with soil are eliminated. However, soil contamination at Site 25 exceeds industrial RGs and poses a threat under a future worker scenario. The BRA calculated a risk of 1.8E-05 for site workers under an industrial use scenario.

Compliance with ARARs: Alternative 2 does not comply with the RGs established for Site 25; Florida Proposed Rule 62-777 is a potential ARAR. No location- or action-specific ARARs are triggered by the institutional controls alternative. Contaminated soil would remain above the RGs.

Institutional Controls: Balancing Criteria

The primary balancing criteria are the technical criteria on which the detailed analysis is based.

Long-Term Effectiveness and Permanence: The long-term effectiveness of institutional controls is limited to the ability to control access to contaminated soil. Soil volumes and concentrations would remain unchanged, and there are no treatment actions that would provide permanence.

Reduction of Toxicity, Mobility, or Volume Through Treatment: The institutional controls alternative would not reduce the mobility, toxicity, or volume of soil contaminants. Contaminants would remain untreated and in place onsite.

Short-Term Effectiveness: Short-term effectiveness assesses an alternative's effect on human health and the environment while it is being implemented. There are no short-term effects resulting from the institutional controls alternative.

Implementability: The institutional controls alternative is technically feasible and easily implemented. No construction issues are associated with this alternative. Current access controls — including military security and limited personnel access to the site — have historically been reliable and will be supplemented through land use restrictions. Administrative coordination is required to implement institutional controls, but no offsite services, materials, specialists, or innovative technologies would be required. There are no implementation risks with Alternative 2.

Cost: Costs include soil monitoring and report preparation every five years for 30 years, plus the cost of establishing the institutional controls. Each sampling and reporting event is estimated to cost $10,000, with a present worth of $24,400 for the 30-year period. Providing the necessary institutional controls is estimated to be a one-time cost of $50,000, for a total cost of $74,400.

Institutional Controls: Modifying Criteria

The modifying criteria are assessed formally after the public-comment period. However, the criteria are factored into identifying the preferred alternatives, as far as they are known.

State/Support Agency Acceptance: FDEP and the USEPA will have the opportunity to review and comment on this FS.

Community Acceptance: These criteria are generally not completed until after public comments on the RI/FS report and the proposed plan are received.

5.5.3 Alternative 3: Asphalt Cover

This alternative uses a physical barrier to cover the two exposed locations where contaminants exceed RGs. In conjunction with the cover alternative, land use will be restricted to industrial to minimize uncontrolled exposure and prevent cover disturbance.

Asphalt Cover: Threshold Criteria

Overall Protection of Human Health and the Environment: The asphalt cover would eliminate the threat of dermal and ingestive contact for current and future site workers. Contaminated soil would be left onsite indefinitely and the cover will be maintained to ensure adequate protection.

This alternative would protect human health and the environment by physically eliminating receptor pathways and controlling access through land use restrictions. Cover construction and maintenance would be easily implemented and current site controls (site security, access control, and fencing) and the LUCA would be adequate to ensure minimal disturbance. Short-term risks during implementation from inhalation and dermal contact would be minimal, and could be controlled using common engineering techniques and use of PPE.

Compliance with ARARs: The asphalt cover with associated institutional controls would comply with RGs for future industrial workers. The potential for contact with soil in which contaminants exceed ISCTLs is eliminated by removing the primary pathways.

The cover would isolate or eliminate contaminants exceeding RGs in environmental media, but not manage solid or hazardous waste. Site grading would need to comply with federal, state, and local air emissions and storm water control regulations. Remedial actions at Site 25 may trigger the following ARARs:

- Storm water discharge requirements as outlined in the *Clean Water Act* (40 CFR 122, 125, 129, 136) and the *Florida Storm Water Discharge Regulations* (FAC 62-25).

Asphalt Cover: Balancing Criteria

Long-Term Effectiveness and Permanence: An asphalt cover would effectively reduce site worker dermal or ingestive contact with contaminated soil, and would require inspection and maintenance. Asphalt covers are generally reliable containment controls; if the asphalt degraded or was removed, repairs could be made to re-establish the cover's integrity.

This alternative eliminates residual risk to site workers by managing Site 25 as an industrial site and restricting land use. The use of these covered soil areas would be controlled institutionally.

Reduction of Toxicity, Mobility, or Volume Through Treatment: Constructing an asphalt cover at Site 25 would not remove, treat, or remediate the contaminated soil; it provides containment only. The cover is considered reversible, because contaminants exceeding RGs under the cover would remain onsite; if the cover fails because of poor maintenance, contaminants may be exposed. This alternative would not reduce toxicity, mobility, or volume through treatment, nor would it satisfy the statutory preference for treatment.

Short-Term Effectiveness: Adverse impacts to the surrounding environment are not anticipated during cover construction; engineering controls would be applied to manage storm water runoff and siltation. Once design plans are approved, actual cover construction would be expected to take less than one month. During construction, workers would be at risk for dermal or ingestive contact with site contaminants; however, this risk would be reduced by proper site work practices and use of PPE.

Implementability: An asphalt cover with institutional controls and limited excavation is technically and administratively feasible. This alternative could be readily applied at the site, because the proposed areas to be covered are easily accessible. Current access controls have been reliable and will be supplemented through the LUCA, and thus, implementing this alternative would merely involve placement of the cover and implementation of the LUCA. Future monitoring and maintenance would involve periodic visual inspections and repairing any damage or degradation. Repairs are easily implemented, and asphalt covering would not require any extraordinary services or materials.

Cost: Costs for this alternative are detailed in Section 5.5.3. The total cost for Alternative 3 including the cover, institutional controls, excavation, and the corrective action contractor is $205,460 (net present value). O&M costs comprise approximately 15% of the net present value.

Asphalt Cover: Modifying Criteria

State/Support Agency Acceptance: FDEP and the USEPA will have the opportunity to review and comment on this FS.

Community Acceptance: These criteria are generally not completed until after public comments on the RI/FS report and the proposed plan are received.

5.5.4 Alternative 4: Excavation and Offsite Disposal

The primary element of this alternative is the excavation of soil contaminated above RGs from the site and disposal in an approved landfill. Land use is restricted to industrial to minimize uncontrolled exposure.

Excavation and Offsite Disposal: Threshold Criteria

Overall Protection of Human Health and the Environment: Excavation and offsite disposal protects human health and the environment by removing contaminated soil posing a risk above RGs. Risk to human health and the environment from contaminants exceeding ISCTLs would be eliminated. Short-term risks during implementation from inhalation and dermal contact would be minimal, and could be controlled with common engineering techniques and use of PPE. The alternative could be easily implemented, and would protect current and future site workers and the environment.

Compliance with ARARs: Excavation would meet chemical-specific ARARs for the associated RGs which protect future industrial site workers. Possible location- and action-specific ARARs include:

- Storm water discharge requirements as outlined in the *Clean Water Act* (40 CFR 122, 125, 129, 136) and the *Florida Storm Water Discharge Regulations* (FAC 62-25).

- USDOT transportation requirements.

- Solid waste disposal requirements (soil is not expected to exhibit hazardous waste characteristics).

Excavation and Offsite Disposal: Balancing Criteria

Long-Term Effectiveness and Permanence: The excavation alternative would remove the contaminated soil from the site and dispose of it in a permitted Subtitle D disposal facility. This alternative would eliminate risk from contaminants exceeding RGs. Soil remaining onsite would not threaten human health under an industrial use scenario. The LUCA will effectively control future land use.

Excavation with disposal in an offsite landfill is a particularly reliable option, because soil removal from the site and would eliminate risks. Some future liability might be incurred through disposal at a landfill.

Reduction of Toxicity, Mobility, or Volume Through Treatment: The excavation with disposal at an offsite landfill alternative would not satisfy the preference for treatment. Although it is anticipated that excavated soil is non-hazardous, TCLP analysis will be performed for verification.

Excavation would eliminate the source area and therefore the contaminants exceeding RGs. This alternative includes the removal of approximately 180 CY of soil from the site which would be isolated in a secure landfill. Because the source would no longer remain onsite, excavation is considered permanent. Mobility, toxicity and volume would not be reduced and the preference for treatment would not be satisfied.

Short-Term Effectiveness: Excavation would be sufficiently removed from the public to reduce health and safety concerns associated with soil removal. Excavation workers would be exposed to increased particulate emissions and might also have more dermal contact with hazardous constituents. However, worker risks can be reduced with dust control technologies and a site-specific health and safety plan that specifies PPE, respiratory protection, etc.

Implementability: Excavation with offsite landfilling is technically and administratively feasible at Site 25. Removal and offsite disposal have been commonly applied at previous sites. The only potential technical problems that might slow down removal activities are materials handling and disposal (standby time between confirmatory sampling and disposal). Landfill debris, if present within the 0- to 2-foot interval, may require disposal at a debris landfill. Areas to be excavated are readily accessible, and no future remedial actions would be required after this alternative is completed.

This alternative would not require any extraordinary services or materials.

Cost: Detailed costs associated with Alternative 4 are presented in Section 5.5.4. Total direct costs for excavation and disposal at a Subtitle D facility are estimated to be $175,490. No O&M costs are associated with this alternative.

Excavation and Offsite Disposal: Modifying Criteria

State/Support Agency Acceptance: FDEP and the USEPA will have the opportunity to review and comment on this FS.

Community Acceptance: These criteria are generally not completed until after public comments on the RI/FS report and the proposed plan are received.

5.6 Site 25 Comparative Analysis of Alternatives

The Site 25 comparative analysis of alternatives is presented in Table 5-11.

Table 5-11
Comparative Analysis of Site 25 Soil Alternatives

Evaluation Criteria	Alternative 1: No Action	Alternative 2: Institutional Controls	Alternative 3: Asphalt Cover	Alternative 4: Excavation and Offsite Disposal
Threshold Criteria				
Protection of human health and the environment (HH&E)	No action is implemented. Because the site's future use is uncontrolled and site contaminants exceed residential standards, there is potential risk to future site residents.	Institutional controls are implemented to restrict land use and therefore minimize uncontrolled exposures. Because locations exceed industrial standards, there is potential risk to current and future site workers.	Asphalt cover will eliminate the dermal contact and ingestion pathway; the LUCA will limit site use to industrial, thus minimizing uncontrolled exposures.	Offsite disposal is a highly effective and reliable way to eliminate risk above RGs. Removal of contaminated media from the site is protective of current and future site workers.
Compliance with ARARs	Current conditions do not meet RGs. While risk is within USEPA's acceptable risk range, onsite risks exceed FDEP's threshold criteria of 1E-06.	Current conditions do not meet RGs. While risk is within USEPA's acceptable risk range, onsite risks exceed FDEP's threshold criteria of 1E-06.	Asphalt cover will eliminate surface soil pathways, and therefore meet RGs. Actions would require compliance with storm water requirements.	Removal would comply with RGs, and all actions would require compliance with storm water requirements.
Balancing Factors				
Long-term effectiveness and permanence	None.	Institutional controls are effective at limiting access. The LUCA will need to be maintained.	Covers are effective at eliminating the risk pathway. Maintenance will be required to ensure effectiveness. The LUCA will restrict and land use and ensure covers are maintained.	Excavation and offsite disposal eliminates risk onsite. The LUCA will restrict land use to industrial and eliminate unrestricted exposures.
Reduction of Toxicity, Mobility, or Volume through Treatment	None.	None.	None.	None.
Short-Term Effectiveness	No risks are associated with the no-action alternative.	No risks are associated with institutional controls.	Implementing the remedy will require less than 1 month; short-term exposures may be reduced by engineering controls and PPE.	Implementing the remedy will require less than 1 month; short-term exposures may be reduced by engineering controls and PPE.

Table 5-11
Comparative Analysis of Site 25 Soil Alternatives

Evaluation Criteria	Alternative 1: No Action	Alternative 2: Institutional Controls	Alternative 3: Asphalt Cover	Alternative 4: Excavation and Offsite Disposal
Balancing Factors (continued)				
Implementability	Technically and administratively feasible. Easily implemented.	Technically and administratively feasible. Easily implemented.	Technically and administratively feasible. Easily implemented.	Technically and administratively feasible. Easily implemented.
Cost	**Capital:** none **Annual:** $10,000, every 5 years **PW:** $24,000	**Capital:** $50,000 **Annual:** $10,000, every 5 years **PW:** $74,000	**Capital:** $175,580 **Annual:** $2,280 **PW:** $207,960	**Capital:** $175,490 **Annual:** $0 **PW:** $175,490
Modifying Criteria				
State/Support Agency Acceptance	FDEP and USEPA will have opportunity to review and comment on this technology.	FDEP and USEPA will have opportunity to review and comment on this technology.	FDEP and USEPA will have opportunity to review and comment on this technology.	FDEP and USEPA will have opportunity to review and comment on this technology.
Community Acceptance	Community acceptance will be established after the public comment period.	Community acceptance will be established after the public comment period.	Community acceptance will be established after the public comment period.	Community acceptance will be established after the public comment period.

6.0 SITE 27 SOIL FEASIBILITY EVALUATION

6.1 Site Description and History

The Radium Dial Shop Sewer extends through Building 709's remaining concrete foundation, which is currently a parking lot. Originally, this site consisted of a small radium dial shop in former Building 709 with a connection to the sanitary sewer. The building foundation is 2 to 4 feet above the surrounding area, with an unpaved easement. The site is approximately 150 feet west of Building 780 (Site 25) and bounded by Farrar and Murray Roads to the south and west, respectively. An adjacent parking lot north of the building foundation is asphalt-paved; a gravel and shell parking lot is next to the foundation's northeastern portion. All area roads are paved with either concrete or asphalt.

6.1.1 Site 27 Surface Soil Comparison with RSCTLs

Twenty-four out of 43 locations at Site 27 exceeded one or more RSCTLs, as shown in Table 6-1 and on Figure 6-1. Samples were collected from multiple intervals in the top 2 feet of soil. These intervals may be designated as -00, -01, or -02. Primary contaminants included arsenic, chromium, lead, mercury, dieldrin, and PAHs. However, the chromium noted at Site 27 is primarily in the trivalent state, which is less mobile and less hazardous to human health than the hexavalent chromium assumed during RSCTL calculation. Hexavalent chromium goals are therefore are not applicable to this site.

Data suggest site contamination is widespread, wherever there is exposed surface soil. Site 27, including paved areas and building foundations, encompasses 2.75 acres. Assuming contamination in the top 2 feet of soil, 8,900 cubic yards of soil exceed RSCTLs at Site 27.

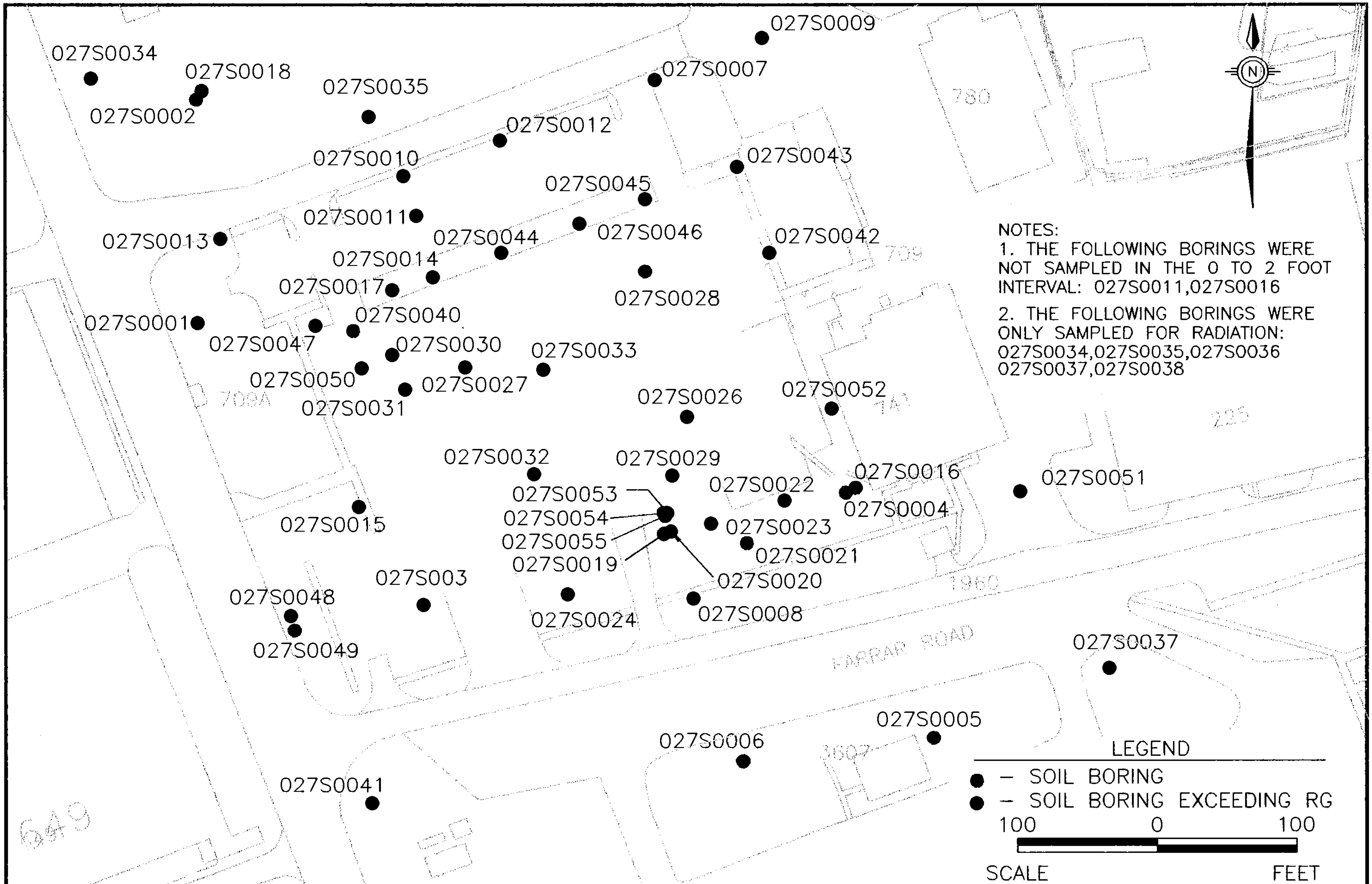


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FIGURE 6–1
SITE 27
SOIL BORING LOCATIONS
EXCEEDING ONE OR MORE RSCTLs

DWG DATE: 04/21/99 | DWG NAME: 0059G010

Table 6-1
Site 27 Surface Soil Locations Exceeding RSCTLs

Location	Contaminant	Concentration (in mg/kg)
027-S-0001-00	Arsenic	1.4
027-S-0001-01	Arsenic	2.8
	Dieldrin	0.8 D
027-S-0002-02	Arsenic	0.99
027-S-0004-01	Chromium	314
027-S-0004-02	Arsenic	1.5
	Benzo(a)anthracene	9.5
	Benzo(a)pyrene	5.6
	Benzo(b)fluoranthene	13 J
	Dibenz(a,h)anthracene	1.2 J
027-S-0005-01	Arsenic	1.7
027-S-0005-02	Arsenic	0.96
027-S-0006-01	Arsenic	2.3
	Dieldrin	0.36
	Benzo(a)pyrene	0.17 J
027-S-0006-02	Arsenic	0.97
027-S-0007-01	Arsenic	1.2
027-S-0007-02	Arsenic	1.2
027-S-0008-01	Arsenic	2.0
027-S-0009-01	Arsenic	3.5
027-S-0009-02	Arsenic	4.4
027-S-0013-02	Arsenic	0.91
027-S-0017-01	Arsenic	0.83
027-S-0017-02	Arsenic	5.9
	Benzo(a)pyrene	0.513 J
027-S-0017-02	Arsenic	1.1
027-S-0019-00	Arsenic	2.1
	Mercury	7.1
	Benzo(a)pyrene	0.11 J

Table 6-1
Site 27 Surface Soil Locations Exceeding RSCTLs

Location	Contaminant	Concentration (in mg/kg)
027-S-0020-00	Arsenic	3.2
	Lead	513 J
027-S-0022-02	Arsenic	1.7
027-S-0026-00	Arsenic	1.6
027-S-0032-02	Arsenic	0.91
027-S-0040-00	Benzo(a)pyrene	0.21 J
027-S-0041-00	Arsenic	4.8
027-S-0042-02	Arsenic	0.93
027-S-0044-02	Arsenic	1.2
027-S-0045-02	Arsenic	0.89 J
027-S-0047-02	Arsenic	1.7
027-S-0049-02	Arsenic	1.3
	Benzo(a)pyrene	0.13 J
027-S-0052-00	Arsenic	1.2
	Chromium	288 J
	Benzo(a)anthracene	1.8
	Benzo(a)pyrene	1.3
	Benzo(b)fluoranthene	2.6 J
	Dibenz(a,h)anthracene	0.18
027-S-0052-01	Arsenic	2.9
	Chromium	223
	Benzo(a)anthracene	2.1 J
	Benzo(a)pyrene	1.5 J
	Benzo(b)fluoranthene	3.1 J
	Dibenz(a,h)anthracene	0.15
027-S-0052-02	Arsenic	3.9
	Chromium	253
	Benzo(a)pyrene	1.1 J
	Benzo(b)fluoranthene	2.4 J
	Dibenz(a,h)anthracene	0.15 J

Table 6-1
Site 27 Surface Soil Locations Exceeding RSCTLs

Location	Contaminant	Concentration (in mg/kg)
027-S-0053-00	Arsenic	2.5
	Lead	1,550
	Mercury	84
027-S-0053-01	Arsenic	1.5
	Chromium	252
	Lead	527
	Mercury	21.8
027-S-0053-02	Mercury	3.4

Notes:
RSCTLs May be found in Appendix C
J = Concentration is estimated.
D = Concentration is obtained from a diluted sample.
mg/kg = milligrams per kilogram.

6.1.2 Site 27 Surface Soil Comparison with ISCTLs

Contaminants at eight locations exceeded ISCTLs, including arsenic, lead, Aroclor 1260, and PAHs, as shown in Table 6-2. Data suggest site contamination is widespread, wherever there is exposed surface soil as shown in Figure 6-2. Locations 027S0001, 027S0052, 027S0053, 027S0041, and 027S0006 exceeded ISCTLs and are exposed at the surface. The assumed soil volume from these sample locations is 1,210 CY.

6.1.3 Site 27 Comparison with Leaching Values Protective of Groundwater

SL-PQGs were evaluated with respect to a poor quality aquifer; exceedances are shown in Table 6-3. Dieldrin was detected above its SL-PQG at four locations, and mercury at one location. The dieldrin exceedances were detected at discontinuous locations (i.e., surrounding samples did not indicate dieldrin at leachable concentrations) as shown in Figure 6-3; these data suggest that the dieldrin detections above the SL-PQG are isolated and there is no large dieldrin

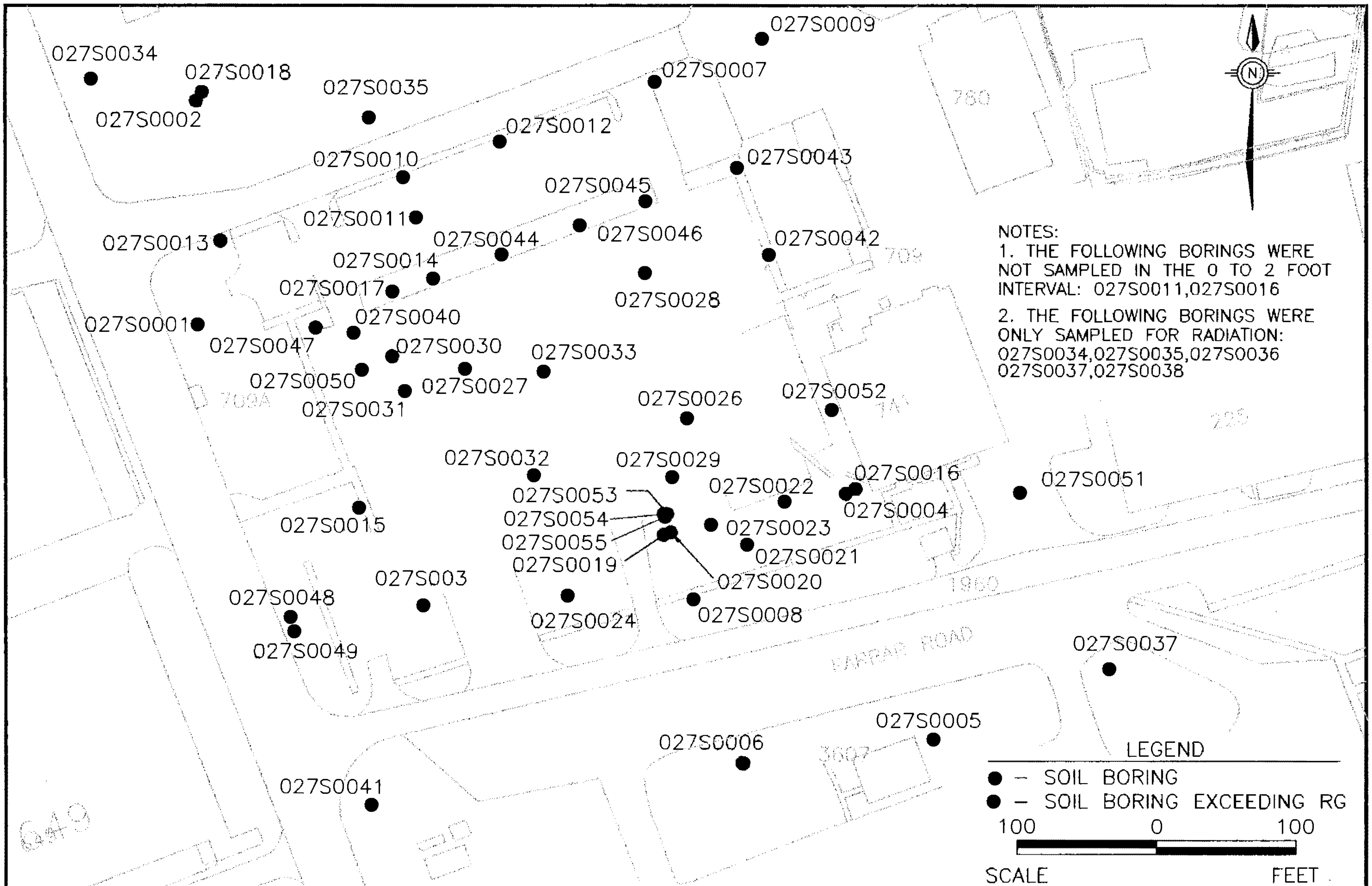

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FIGURE 6-2
SITE 27
SOIL BORING LOCATIONS
EXCEEDING ONE OR MORE ISCTLs

DWG DATE: 04/21/99	DWG NAME: 0059G011

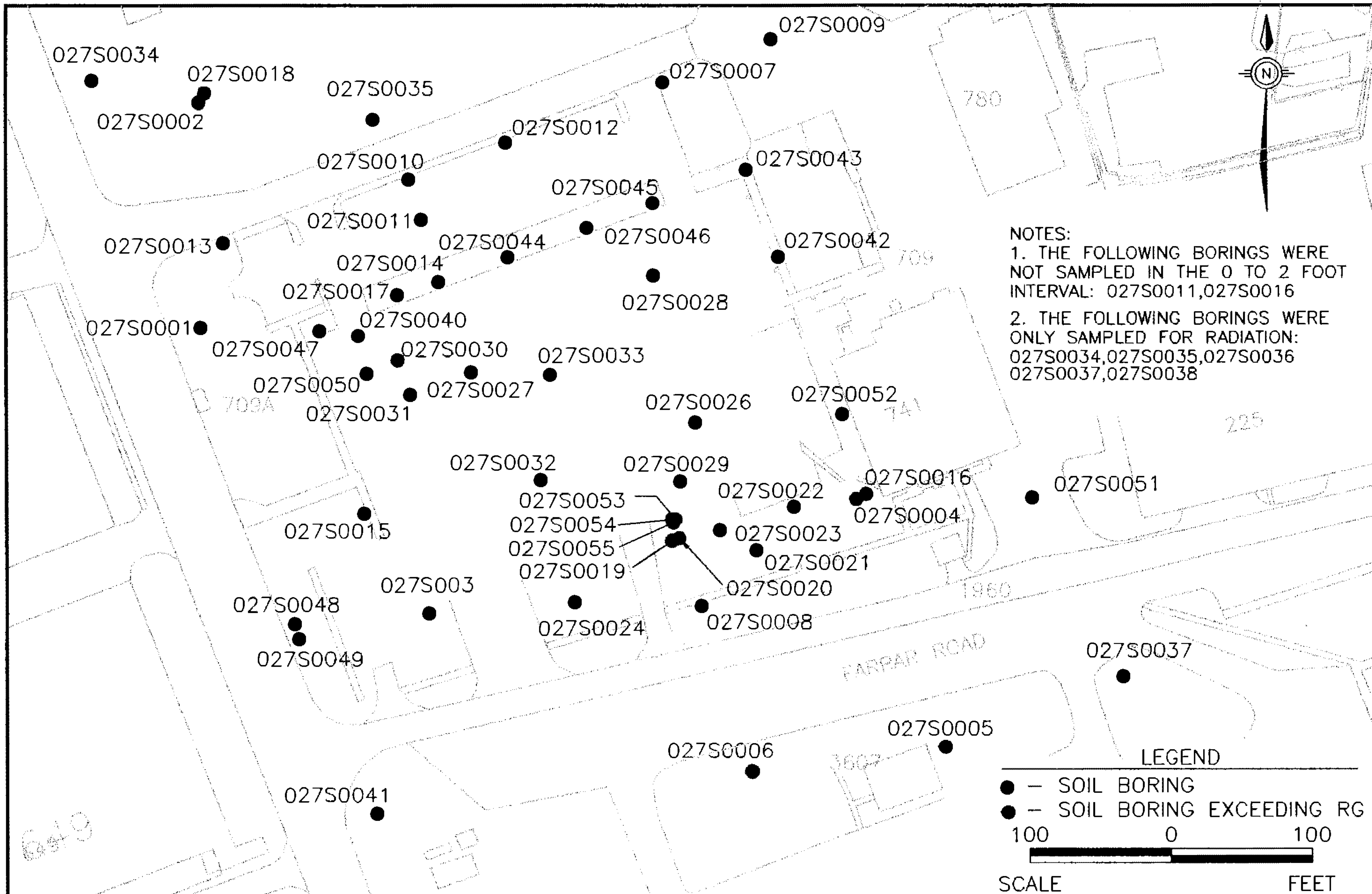

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FIGURE 6-3
SITE 27
SOIL BORING LOCATIONS
EXCEEDING ONE OR MORE
SL-PQG CRITERIA

DWG DATE: 04/21/99 | DWG NAME: 0059G012

Table 6-2
Site 27 Surface Soil Locations Exceeding ISCTLs

Location	Contaminant	Concentration (in mg/kg)
027-S-0001-01	Dieldrin	0.8 D
027-S-0004-02	Benzo(a)anthracene	9.5
	Benzo(a)pyrene	5.6
	Benzo(b)fluoranthene	13 J
027-S-0006-01	Dieldrin	0.36
027-S-0009-02	Arsenic	4.4
027-S-0017-02	Arsenic	5.9
027-S-0041-00	Arsenic	4.8 J
027-S-0052-00	Benzo(a)pyrene	1.3
027-S-0052-01	Benzo(a)pyrene	1.5 J
027-S-0052-02	Benzo(a)pyrene	1.1 J
027-S-0053-00	Lead	1,550
	Mercury	84

Notes:
ISCTLs may be found in Appendix C
J = Concentration is estimated.
D = Concentration is obtained from a diluted sample.
mg/kg = milligrams per kilogram.

Table 6-3
Site 27 Locations Exceeding SL-PQGs

Location	Contaminant	Concentration (in mg/kg)
027-S-0001-01	Dieldrin	0.8 D
027-S-0006-01	Dieldrin	0.36 D
027-S-0049-02	Dieldrin	0.047
027-S-0052-00	Dieldrin	0.041
027-S-0053-00	Mercury	84
027-S-0053-01	Mercury	21.8

Notes:
SL-PQG criteria may be found in Appendix C
J = Concentration is estimated.
D = Concentration is obtained from a diluted sample.
mg/kg = milligrams per kilogram.

source area. Moreover, dieldrin was not quantified in groundwater at concentrations exceeding GW-PQG criteria. Therefore, risks posed by soil leachability to groundwater are considered minimal; dieldrin contaminated soil will not be considered during remedial actions.

Mercury was only detected at one location, 027-S-0053; adjacent borings did not contain mercury above the SL-PQG, suggesting that no large mercury source area exists. Mercury was not detected in Site 27 groundwater at concentrations above GW-PQG criteria.

6.1.4 Site 27 Comparison with Leaching Values Protective of Water Bodies

Because Site 27 is not adjacent to any surface water bodies, comparison with soil leaching criteria protective of surface water was not performed.

6.2 Remedial Goals

RGs for OU2 have been proposed for the protection of human health and the environment given current and future land use. OU2 has historically been used for industrial purposes, as described in Section 1; future use is expected to remain the same. Future risk to human health will be minimized by maintaining OU 2 as an industrial site. Institutional controls will be required for both soil and groundwater to limit exposures above appropriate criteria.

RAOs

- Protect the health of current and future site workers. ISCTLs will be used as RGs.
- Protect the environment by ensuring future soil-to-groundwater transfers are protective of a poor quality aquifer. SL-PQG criteria will be used to determine risk to the underlying aquifer.

6.2.1 Surface Soil Remediation Goals

Surface soil RGs are based on ISCTLs; land use conditions are not expected to change. Table 6-4 presents the RGs for surface soil at OU2.

Table 6-4
Contaminant-Specific Remediation Goals for Surface Soil at Site 27

Contaminant	RG (in mg/kg)
Arsenic	3.7
Lead	920
Mercury	26
Dieldrin	0.3
Benzo(a)anthracene	5
Benzo(a)pyrene	0.5
Benzo(b)fluoranthene	4.8

6.2.2 Subsurface Soil Remediation Goals

Based on a comparison of site analytical data with Florida SL-PQG criteria, as discussed in Sections 6.1.3 and 6.1.4, contamination detected above SL-PQG and SL-SW criteria does not represent a current or potential source for future groundwater contamination; there is no distinguishable source mass present at Site 27. Therefore, no subsurface remediation goals have been established for Site 27.

6.2.3 Soil Volumes

Table 6-5 identifies locations exceeding one or more ISCTLs. This table also identifies surface soil conditions and impacted soil volumes associated with each location.

Table 6-5
Site 27 Surface Soil Volumes Exceeding RGs (in mg/kg)

Location	Contaminant	Concentration (in mg/kg)	Comment
027-S-0001-01	Dieldrin	0.8 D	Exposed surface soil. Impacted area 60 ft by 60 ft by 2 ft. Total volume 267 CY.
027-S-0004-02	Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene	9.5 5.6 13 J	Exposed surface soil. Impacted area 40 ft by 65 ft by 2 ft. Total volume 193 CY.
027-S-0006-01	Dieldrin	0.36	Exposed surface soil. Impacted area 50 ft by 50 ft by 2 ft. Total volume 370 CY.
027-S-0009-02	Arsenic	4.4	Paved. No exposure pathway.
027-S-0017-02	Arsenic	5.9	Paved. No exposure pathway.
027-S-0041-00	Arsenic	4.8 J	Exposed surface soil. Impacted area 60 ft by 70 ft by 2 ft. Total volume 311 CY.
027-S-0052-00	Benzo(a)pyrene	1.3	Exposed surface soil. Impacted area 15 ft by 65 ft by 2 ft. Total volume 72 CY.
027-S-0052-01	Benzo(a)pyrene	1.5 J	
027-S-0052-02	Benzo(a)pyrene	1.1 J	
027-S-0053-00	Lead	1,550	Collocated with radium spill area. This area will be addressed by RASO.
	Mercury	84	

Notes:
J = Concentration is estimated.
D = Concentration is obtained from a diluted sample.
mg/kg = milligrams per kilogram.

The total soil volume impacted at Site 27 is approximately 1,210 CY. The areal distribution of contaminated media is shown in Figure 6-4. This volume does not contain soil covered by pavement or building foundations, nor does it include soil with radiological contamination. Radiological contamination will be addressed by RASO.

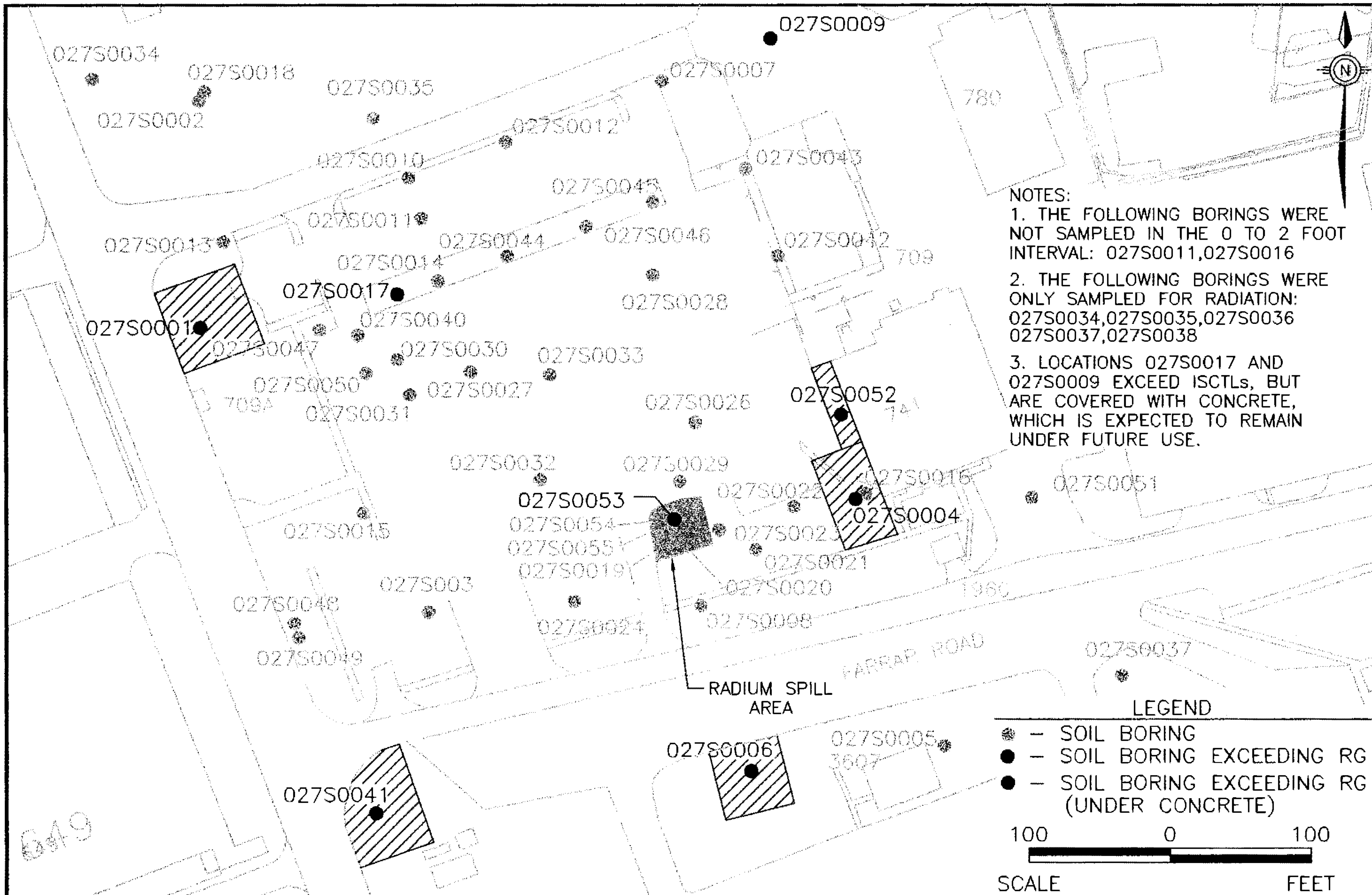

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FIGURE 6–4
SITE 27
AREAS EXCEEDING RGs

DWG DATE: 04/22/99 | DWG NAME: 0059G013

6.3 Site 27 Soil Technologies Screening

Table 6-6 presents various remedial technologies applicable to PAHs, dieldrin, and arsenic in soil. This table evaluates each technology's applicability to Site 27, and is used to screen out technologies which are infeasible given site conditions. As discussed in Section 2, technologies have been screened for implementability, effectiveness, and cost.

The technologies retained for use at Site 27 after screening are:

- No Action, as required by the NCP.
- Institutional controls, which will be needed to maintain the industrial-use classification
- Capping
- Excavation with offsite disposal

Table 6-6 includes screening comments for each technology; the rationale for discarding other potential technologies is discussed in the following paragraphs.

A key factor in evaluating remedial options is the contaminated media's proximity to radiological contamination. Because two areas that pose risk (027S0004 and 027S0052) are adjacent to radium contamination at Site 27, it is possible that contamination may overlap. In situ techniques may be futile if soil is subsequently excavated by RASO, or if these actions interfere with RASO's removal. Similarly, if soil is excavated, treated, and replaced, there is a chance that the RASO removal may excavate the clean soil for disposal. Conversely, if radium-contaminated soil is inadvertently treated during Site 27 remedial actions, cross-contamination of soil and equipment could occur. Any actions considered should be integrated with RASO plans for Site 27 soil. The following comments assume complete segregation of chemical- and radium-contaminated soil.

In situ bioremediation techniques and phytoremediation were discarded because of land use considerations at Site 27, the presence of multiple contaminants onsite, and low RGs. Arsenic is not amenable to biological treatment, which eliminates approximately one-third the total volume requiring treatment at Site 27. PAHs and dieldrin, though technically treatable, will be difficult to manage because of the small remaining volumes. For example, PAH contaminated soil near 027S0004 and 027S0052. is concentrated in a narrow strip adjacent to Building 741, and has a total volume of 265 CY; management of in situ actions in this narrowly defined strip will be difficult. Borings 027S0006 and 027S0001 are isolated from each other, leaving two small plots to be remediated (boring 027S0006 is 50 ft by 50 ft; boring 027S0001 is 60 ft by 60 ft). Logistically, implementation would be costly (running water to each contaminated area, setting up the necessary amendment feeds, etc. In addition, current and future land use is expected to remain industrial. These areas are adjacent to parking lot and access areas for buildings 741, 3607, and 3220. Typical bioremediation technologies would require some degree of tillage, moisture control, or other amendment; as a result access to these buildings may be restricted during the remediation period. In addition, because PAHs and pesticides are slower to degrade than other contaminants, remediation timeframes will be comparatively longer than other technologies. Finally, given the low initial concentrations for these contaminants, and the low RGs, particularly for benzo(a)pyrene (0.5 mg/kg) and dieldrin (0.3 mg/kg), the bioavailability of contaminants becomes a significant question; it is possible that contaminant concentrations near the RG will be insufficient to sustain an active microbial population.

Similarly, in situ and ex situ solidification/stabilization were discarded as possible technologies because of adjacent land use. Solidification/stabilization is primarily used to minimize leaching and contaminant mobility, which are not problematic for PAHs and pesticides. While solidification/ stabilization is applicable to arsenic contaminated soil, contaminant concentrations at 027S0041 are not high enough to threaten the underlying aquifer. Rather, arsenic contamination was identified because it exceeded a human health goal for industrial site workers.

Ex situ reactor-based treatment, such as solid and slurry phase biodegradation, soil washing, and chemical oxidation were also eliminated based on the small volume of soil for each contaminant. As discussed above, the three contaminants are segregated by location: PAHs (027S0004 and 027S0052, 265 CY), dieldrin (027S0006 and 027S0001, 637 CY), and arsenic (027S0041, 311 CY). Each of these technologies requires construction of infrastrucutre, which may range from haybales and polyethylene liners for a small landfarming unit, to mixers and contact chambers for a soil washing unit. Treatment requirements for each contaminant may be different. Once again, the construction of treatment units for such small volumes of soil is likely to be cost-prohibitive.

Thermal treatments, such as incineration, pyrolysis, and thermal desorption, although effective for organic compounds, were discarded because of the high costs and implementation obstacles associated with meeting ARARs. If thermal treatment is identified at another site as a viable option, consolidation might be considered. However, contamination across OU 2 is significantly low enough that other treatment options will likely meet the statutory preference for treatment.

Table 6-6
Soil Technology Screening — Site 27

Technology	Description	Implementability	Effectiveness	Cost
CONTAINMENT				
Surface Cap	Capping is a containment technology that will limit human contact with soil and reduce infiltration of rainwater through contaminated soil. Capping materials include soil, asphalt, and concrete.	Currently, Building 709's foundation is used as a parking lot. Adjacent areas may be paved easily. Impacted areas south of Farrar Road could be integrated into existing parking areas for Buildings 3607 and 3220. Any actions that could change surface features, however, should be coordinated with radioactive soil remediation plans being developed by RASO.	Caps eliminate the ingestion/ inhalation/contact pathway, and therefore are effective at reducing risk to human health. With ongoing maintenance, the long-term effectiveness of a cap is high. Capping is an effective means of eliminating risk pathways, but it does not meet any preference for treatment, nor does it reduce contaminant toxicity, mobility, or volume.	Because this cap is intended only to eliminate a risk pathway and not to isolate waste or reduce infiltration, a multi-layer cap is not required. Costs for common capping material, such as soil, asphalt, or concrete, are comparatively low. Maintenance costs are also low.

Table 6-6
Soil Technology Screening — Site 27

Technology	Description	Implementability	Effectiveness	Cost
		IN SITU TREATMENT TECHNOLOGIES		
Bioremediation	Naturally occurring microbes are stimulated by amending contaminated soils to enhance biodegradation. Nutrients, oxygen, hydrogen peroxide, and other amendments may enhance biodegradation and contaminant desorption from subsurface materials. Amendments may be added through solution (such as water), or they may be mixed into the soil using tillers or rippers. When mechanical mixing is required, such as with in situ land farming applications, in situ bioremediation effectiveness is limited at depth. Similarly, effectiveness may be limited if deeper zones exhibit preferential pathways and nutrient/amendment delivery is irregular. Bioremediation may occur in aerobic and anaerobic conditions. In some cases, commercially obtained microbes may be used to supplement native polulations.	Bioremediation may be technically implementable at Site 27; contamination is limited to the top 2 feet bgs, and thus may easily be controlled. However, given current and future site use, implementation of bioremediation at Site 27 will likely be difficult. Impacted areas are adjacent to current activities; the access required for amendment and monitoring would likely limit the usefulness of these areas during the remediation effort. Any actions should be coordinated with radioactive soil remediation plans being developed by RASO.	In situ bioremediation may be less effective at Site 27 due to the varying contaminants which exceed ISCTLs. Of site contaminants, only PAHs and dieldrin may be treated using biodegradation; arsenic contamination is not amenable to biological techniques. Because contamination is limited to the top 2 feet, it may be easy to monitor and control this remedy. In addition, the porous nature of the impacted media may facilitate uniform amendment delivery. Degradation of PAH and pesticide compounds is typically slower than more amenable compounds, such as BTEX. Although high concentrations of heavy metals, highly chlorinated organics, long-chain hydrocarbons, or inorganic salts are likely to be toxic to microorganisms, these conditions do not exist at Site 27. Importantly, the remedial goal for dieldrin is low, 0.3 mg/kg; it may be difficult to sustain a microbial population at this low concentration. Bioremediation enhances biodegradation, and therefore is considered a destructive technology.	Bioremediation costs are typically variable because the need for amendments is highly site specific. However, in situ bioremediation costs are typically lower than other insitu technologies such as SVE. This option is not likely to be cost effective given the small volumes of soil with different contaminant types requiring treatment at Site 27.

Table 6-6
Soil Technology Screening — Site 27

Technology	Description	Implementability	Effectiveness	Cost
Bioventing	Air is either extracted from or injected into the unsaturated soils to increase oxygen concentrations and stimulate biological activity. Bioventing is applicable for any contaminant that more readily degrades aerobically than anaerobically. This process is used to deliver amendments to zones deeper than what can be managed by bioremediation practices alone. Flow rates are much lower than soil vapor extraction, minimizing volatilization and release of contaminants to the atmosphere. Where preferential pathways exist in the vadose zone, air flow may not reach all contaminated media.	Bioventing is not technically implementable to Site 27, given that contamination is limited to the 0- to 2-foot interval. Administrative implementability is also limited given current and future site use. Any actions that could change surface features, however, should be coordinated with radioactive soil remediation plans being developed by RASO.	Bioventing is unlikely to be more effective than natural degradation processes at this site, given that surface soil is already highly oxygenated. Bioventing enhances biodegradation, and therefore is considered a destructive technology.	Bioventing is relatively inexpensive, though ongoing use of blowers and ancillary piping will require O&M. This option is not likely to be cost effective given the small volumes of soil with different contaminant types requiring treatment at Site 27.

Table 6-6
Soil Technology Screening — Site 27

Technology	Description	Implementability	Effectiveness	Cost
Phytoremediation	Phytoremediation is the use of plants to remove, contain, and/or degrade contaminants. Examples include: enhanced rhizosphere biodegradation, phytoaccumulation, phytodegradation, and phytostabilization. Climatic or hydrologic conditions may restrict the rate of growth of the remediation plants.	Phytoremediation may be technically implementable at Site 27; contamination is limited to the top 2 feet bgs, and thus there are likely a wide variety of plants which may be used to remediate site soil. Implementation of phytoremediation will require identification of a plant or plants amenable to all site compounds (arsenic, lead, PAHs, and PCBs), and optimization of growing conditions. Because remediation time frames may be long, plans for future site use may be impacted by phytoremediation. Implementation of phytoremediation at Site 27 may be inconsistent with current and future site activities. Impacted areas posing risk are immediately adjacent to roadways and parking lots for Buildings 741, 3607, and 3220. Moreover, impacted areas are discontinuous and scattered across the site. Any actions should be coordinated with radioactive soil remediation plans being developed by RASO. Additionally, due to time required for remediation, plans for future site use may be impacted by phytoremediation.	Phytoremediation is an innovative technology that may be effective at Site 27 given that contamination is limited to the top 2 feet, well within the root zones of some plants. Shallow contamination is easily monitored and controlled. Although high concentrations of hazardous materials can be toxic to plants, contaminant concentrations at Site 27 are not excessive. Phytoremediation may be a destructive remediation technology, depending on the type of plants used. It may also be used as a containment or immobilization strategy, binding contaminants in soil or biomass. However, there is concern that phytoremediation is reversible. Additionally, plants that have died or which are removed from the site may require special management or handling due to concentrated contaminants within the biomass.	Costs for phytoremediation are expected to be low compared with other in situ techniques. Maintenance costs are also expected to be relatively low, consisting of monitoring and watering costs. This option is not likely to be cost effective given the small volumes of soil with different contaminant types requiring treatment at Site 27.

Table 6-6
Soil Technology Screening — Site 27

Technology	Description	Implementability	Effectiveness	Cost
In Situ Solidification/ Stabilization	In situ stabilization immobilizes contaminants by mixing site soil with portland cement, lime, or a chemical reagent to reduce the mobility of the contaminant. Large augering equipment is used to mix soils in place with the reagent. This technology will likely leave a solid mass, similar to concrete, onsite.	This technology is technically implementable at Site 27. Contaminated soil is limited to the 0- to 2-foot interval, which is easily mixed. The stabilized mass may be left in place, and use of the area for parking and access may continue. Any actions should be coordinated with radioactive soil remediation plans being developed by RASO.	Solidification/stabilization can be an effective containment strategy for organic compounds. However, this technology works better for inorganics including radionuclides. Some organic-contaminated soils may delay or inhibit reactions necessary for solidification. Long-term, the stabilized mass can degrade, particularly if subject to repeated abuse. Solidification/stabilization is not a permanent treatment technology and does not remove or destroy contaminants; rather, contaminants are immobilized. Treated media typically must be managed long term (e.g., through institutional controls and monitoring).	Solidification/stabilization costs typically vary given the stabilizing material required (e.g., fly ash, portland cement, etc.). However, these costs are typically low compared with destructive in situ options. This option is not likely to be cost effective given the small volumes of soil with different contaminant types requiring treatment at Site 27.

Table 6-6
Soil Technology Screening — Site 27

Technology	Description	Implementability	Effectiveness	Cost
		EX SITU TREATMENT TECHNOLOGIES		
Solid-phase biodegradation. • Biopiles • White rot fungus • Landfarming	Excavated soils are mixed with amendments, nutrients, enzymes, or fillers and placed in aboveground enclosures. Mixing may be required, as in a traditional landfarming application. Conversely, biopiles may be used simply to deliver oxygen uniformly throughout a large pile. Ex situ biological systems may be designed to degrade specific compounds and maintain specified degradation conditions (aerobic vs. anaerobic). Mechanical mixing, such as tilling or turning of windrows, may be required.	Although technically implementable, the small volume of contaminated soil present at Site 27 may limit the administrative implementability of this technology. Each contaminant may require different biological conditions for optimum degradation; therefore, three different approaches may be required (one for PAHs, one for dieldrin, and one for arsenic) Existing structures and utilities may impede or restrict excavation. Moreover, a large amount of space is required for solid phase ex situ bioremedation. Any actions should be coordinated with radioactive soil remediation plans being developed by RASO.	Ex situ bioremediation systems may be tailored to the specific contaminant requiring treatment. Biodegradation is typically limited to organic compounds, and heavy metals may be toxic to microorganisms. Remediation half-lives for PAHs and pesticides may be slower than more degradable compounds, such as BTEX, which may extend the remediation time frame. Arsenic concentrations will not be reduced through biological activity. It may be necessary to isolate contaminated soil with similar contaminant concentrations and thus optimize treatment specifically for PAHs and dieldrin; even then the remediation goal for dieldrin, 0.3 mg/kg is low, and may be inadequate to sustain a microbial population without a supplemental carbon source. Solid phase bioremediation is a permanent, destructive technology.	Ex situ solid phase bioredmeation is inexpensive compared with other ex situ techniques. However, given the need to design specific nutrient amendments and process control systems, more recalcitrant organics are typically more expensive to treat. This option is likely not cost effective given the small volume of soil contaminated at Site 27.

Table 6-6
Soil Technology Screening — Site 27

Technology	Description	Implementability	Effectiveness	Cost
Slurry Phase Biological Treatment	Slurry-phase bioreactors containing co-metabolites and specially adapted microorganisms can be used to treat halogenated VOCs and SVOCs, pesticides, and PCBs. An aqueous slurry is created by combining soil with water and other additives. The slurry is mixed continuously to keep solids suspended and microorganisms in contact with the soil contaminants. Upon completion of the process, the slurry is dewatered and the treated soil is disposed of.	Although technically implementable, the small volume of contaminated soil present at Site 27 may limit the administrative implementability of this technology. Existing structures and utilities may impede or restrict excavation. Moreover, a large amount of space is required for slurry phase ex situ bioremediation. Any actions should be coordinated with radioactive soil remediation plans being developed by RASO.	Slurry-phase bioreactors are used primarily to treat nonhalogenated SVOCs and VOCs in excavated soils or dredged sediments. Ex situ bioremediation systems may be tailored to the specific contaminant requiring treatment. Biodegradation is typically limited to organic compounds, and heavy metals may be toxic to microorganisms. Arsenic contamination at Site 27 will not be treated by biological remedies. Remediation half-lives for PAHs and pesticides may be slower than more degradable compounds, such as BTEX, which may extend the remediation time frame. If supplemental carbon is required to sustain microbes and improve treatment system effectiveness, application rates can be easily controlled in a slurry system. Slurry phase bioremediation is a permanent, destructive technology.	Ex situ slurry phase bioremediation is expensive compared with other biological techniques, due to the controls and materials handling required. This option is likely not cost effective given the small volume of soil contaminated at Site 27.

Table 6-6
Soil Technology Screening — Site 27

Technology	Description	Implementability	Effectiveness	Cost
Soil Washing • Chemical Extraction • Acid Extraction • Solvent Extraction • Separation Techniques	Excavated soil is washed with aqueous-based solutions to separate contaminants sorbed onto fine particles from the rest of the soil matrix. The fractions of soil to be treated are processed in a slurry with specific leachant mixtures to ionize target metals. The solvent/waste mixture is then treated further treated to develop a concentrated leaching solution. which may be treated or disposed offsite. Traditional soil washing options may also include separation techniques which concentrate contaminated solids through physical and chemical means. These processes seek to detach contaminants from their medium (e.g., soil, sand, or other binding material). Gravity separation, magnetic separation, and sieving/physical separation are examples of this technology.	Although technically implementable, the small volume of contaminated soil present at Site 27 may limit the administrative implementability of this technology. The system must be designed to remove each contaminant identified at Site 27: PAHs, dieldrin, and arsenic This may mean three different solvents and/or processes are used.. Existing structures and utilities may impede or restrict excavation. Soil washing systems will require operational space as well as possible water and sewer connections. Any actions should be coordinated with radioactive soil remediation plans being developed by RASO.	Overall, this technology is effective at removing SVOCs and inorganics. It is less effective at treating VOCs. In general, acid extraction techniques are suitable for treating soils contaminated by heavy metals. Solvent extraction has been shown to be effective in treating soils containing primarily organic contaminants, but is generally least effective on very high molecular-weight organic and very hydrophilic substances. Effectiveness may be better controlled by segregating soil (by contaminant type) and treating each contaminant exclusively. Soils with higher clay content may reduce extraction efficiency and require longer contact times. High humic content in soil may require pretreatment. It may be difficult to remove organics adsorbed to clay-size particles. Soil washing is a permanent treatment technology which removes contaminants from soil media to another (e.g., solvent, carbon, etc.). Treatment residuals then may require treatment or disposal. Soil washing solvents may also pose environmental risks.	Soil washing is typically an expensive remediation alternative because of the highly site-specific design requirements and the need to treat and/or dispose of the leaching solvent. This option is likely not cost effective given the small volume of soil contaminated at Site 27.

Table 6-6
Soil Technology Screening — Site 27

Technology	Description	Implementability	Effectiveness	Cost
Chemical/ Physical Oxidation • permanganate flooding • Fenton's reagent • Wet air oxidation • Supercritical water oxidation	Chemical oxidation is a process in which the oxidation state of a contaminant is increased while the oxidation state of the reactant is decreased. The reactant can be another element, including the oxygen molecule, or it may be a chemical species containing oxygen, such as hydrogen peroxide or chlorine dioxide. In the case of physical oxidation technologies, wet air oxidation and supercritical water oxidation both use high pressure and temperature to treat organic contaminants.	Chemical oxidation is not technically implementable at Site 27, given the low soil volumes. Administrative implementability is also limited given current and future site use. Any actions should be coordinated with radioactive soil remediation plans being developed by RASO. Iron and manganese in the soil will compete with contaminants for oxygen.	This technology is effective in treating media contaminated with halogenated and non-halogenated volatiles and semivolatiles, PCBs, pesticides, cyanides, and volatile and nonvolatile metals. Wet air oxidation can treat hydrocarbons and other organic compounds. Supercritical water oxidation is applicable for PCBs and other stable compounds. Oxidation is a permanent treatment technology, in which contaminants are destroyed.	Costs for chemical oxidation processes may be comparable to soil washing costs, given the need to construct and operate ex situ reactors, and the need to control reagents and reactor conditions. Costs may vary widely with the type of oxidation technique implemented. The small soil volumes at Site 27 likely render this technology cost-prohibitive.
Ex Situ Solidification/ Stabilization	Contaminants are physically bound or encased within a stabilized mass, or chemical reactions are induced with stabilizing agents. The contaminants are not removed or destroyed, but their mobility is reduced. Examples of S/S technologies include: bituminization, emulsified asphalt, modified sulfur cement, polyethylene extrusion, pozzolan/portland cement, radioactive waste solidification, sludge stabilization, and soluble phosphates.	Ex situ stabilization/ solidification is the best-demonstrated technology for multiple compounds. It is technically implementable, and often required to render contaminants non-hazardous before offsite disposal. Site contaminants are non-hazardous PAHs, dieldrin, and arsenic, and it is unlikely that it will be necessary to render these concentrations lower to meet treatment standards. Any actions that could change surface features, however, should be coordinated with radioactive soil remediation plans being developed by RASO.	This technology works well for inorganics including radionuclides. Although organic-contaminated soil may be treated with solidification/stabilization, some organics can delay or inhibit reactions necessary for solidification. Solidification/ stabilization is not a permanent treatment technology and does not remove or destroy contaminants; rather, contaminants are immobilized. Treated media typically must be managed appropriately, i.e., landfilled or contained onsite. Where used as asphalt or similar covers, degradation due to normal asphalt weathering should be considered.	Solidification/stabilization costs typically vary given the stabilizing material required (e.g., fly ash, portland cement, etc.). However, ex situ stabilization/ solidification is inexpensive, compared with other ex situ technologies. This option is not likely to be cost effective given the small volumes of soil with different contaminant types requiring treatment at Site 27.

Table 6-6
Soil Technology Screening — Site 27

Technology	Description	Implementability	Effectiveness	Cost
Incineration/ Pyrolysis	Incineration burns contaminated sediment at high temperatures (1,600° - 2,200°F) to volatilize and combust organic contaminants. A combustion gas treatment system must be included with the incinerator. The circulating bed combustor, fluidized bed reactor, infrared combustor, and rotary kiln are several types of incinerators. Pyrolysis chemically changes contaminated sediment by heating it in the absence of air. Pyrolysis can be achieved by limiting oxygen to rotary kilns and fluidized bed reactors. Molten salt destruction is another example of pyrolysis.	Incineration/ pyrolysis is not technically implementable at Site 27, given that soil volumes are very low – likely inadequate for a trial burn. The lead agency will likely be reluctant to construct an incineration unit for a small-volume, short-term project. Administrative implementability will be limited by the need for submitting documentation and testing the unit's compliance with ARARs. Administrative implementability is also limited given current and future site use. Any actions should be coordinated with radioactive soil remediation plans being developed by RASO. Highly abrasive feed can damage the processor unit. The technology requires drying the soil to achieve less than 1% moisture content.	Incineration may be effective in treating organic-contaminated soil, but not for soil with metals as the primary contaminants. The target contaminant groups for pyrolysis are SVOCs and pesticides. Pyrolysis is not effective in either destroying or physically separating inorganics from the contaminated medium. Volatile metals may be removed by the higher temperatures, but are not destroyed. Incineration is a permanent treatment technology; COCs are destroyed during treatment.	Incineration/ pyrolysis are typically very expensive remedial options compared with other ex situ remediation. The small soil volumes and low contaminant concentrations at Site 27 likely render this technology cost prohibitive.

Table 6-6
Soil Technology Screening — Site 27

Technology	Description	Implementability	Effectiveness	Cost
Thermal Desorption	Soil is generally heated between 200° and 1,000°F to separate VOCs, water, and some SVOCs from the solids into a gas stream. The organics in the gas stream must be treated or captured. Thermal desorption may be used at high or low temperatures depending on the volatility of the contaminants.	Thermal desportion is technically implementable at Site 27. Some thermal desorbers may be regulated as incinerators, depending on construction. Testing and optimization would be required. Aministrative implementability will likely be limited given current and future site use. Any actions should be coordinated with radioactive soil remediation plans being developed by RASO. Highly abrasive feed can damage the processor unit. Although clay and silty soils and soil with high humic content increase reaction time due to binding of contaminants, this problem would not be anticipated for Site 27.	Thermal desorption units are effective at removing primarily organic contaminants. Residence time and temperature inside the unit can be varied to volatilize recalcitrant organics. Inorganic contaminants or metals that are not particularly volatile will not be effectively removed by thermal desorption. Arsenic contaminated soil will not be addressed by this technology. Vapor phase organics must be concentrated and treated or otherwise disposed of. Thermal desorption is a permanent treatment technology which will eliminate risk by removing COCs from site soil.	Although less expensive than other ex situ thermal treatment methods, thermal desorption is still comparatively expensive. Costs increase with the degree of materials handling, pre-and post- treatment, and off-gas controls required. The small soil volumes at Site 27 likely render this technology cost prohibitive.

Table 6-6
Soil Technology Screening — Site 27

Technology	Description	Implementability	Effectiveness	Cost
Excavation and Offsite Disposal	Contaminated soil is excavated and disposed of offsite at a licensed waste disposal facility.	Excavation with offsite disposal is both technically and administratively implementable at Site 27. Contaminated media can be removed and disposed offsite. The excavated areas can then be backfilled with clean fill with minimal impact to operations at adjacent buildings. Testing will be required before the soil is disposed of; TCLP results may impact disposal options. Transporting the soil through populated areas may affect community acceptance; however, given the small volumes anticipated at Site 27, this is not expected to be an issue. Any actions which may change surface features should be coordinated with radioactive soil remediation plans being developed by RASO.	Excavation with offsite disposal is expected to be an effective remediation option. It is effective for all contaminants because the risk pathway is eliminated. This is a permanent remedial technology.	Costs for excavation and offsite disposal vary, depending on whether waste is classified as hazardous. However, compared with other options (including treatment or disposal at an incineration facility), landfilling is relatively less expensive.

6.4 Site 27 Assembly of Alternatives

The following alternatives have been retained for Site 27 soil.

- Alternative 1: No Action
- Alternative 2: Institutional controls
- Alternative 3: Asphalt Cap
- Alternative 4: Excavation with Offsite Disposal

6.4.1 Alternative 1: No Action

Under this alternative, no changes would be made to existing site operations or exposure scenarios. While the current and projected land use for this site is expected to remain industrial, there are no institutional controls to guarantee the exposure pathway would remain industrial. Without controls, a residential scenario must be assumed in which all existing pavement and buildings are removed.

Implementability

The no-action alternative could be easily implemented. The Navy would be required to perform a 5-year review to assess adequacy of the alternative.

Effectiveness

The no-action alternative is not effective at protecting human health, as contaminants above residential and industrial SCTLs are left onsite. As discussed in the BRA, if residential exposures occur, Site 27 soil presents a combined soil ingestion/contact pathway risk of 2.5E-05 to potential future site residents; this risk is within the allowable range cited in the NCP (1E-06 to 1E-04), and exceeds the FDEP threshold criteria of 1E-06.

Cost

Table 6-7 presents the costs associated with the no-action alternative.

Table 6-7
Alternative 1 — Costs for No Action

Action	Quantity	Cost per Unit	Total Cost
Five Year Review	LS	$10,000	$10,000
Present value sub total at 6% discount over 30 years			$24,400
Total Cost			**$24,400**

Notes:
LS = Lump sum
Cost based on review once every five years for 30 years.

6.4.2 Alternative 2: Institutional Controls

No remedial actions will be implemented under this alternative. LUCAs would be implemented to limit access and property use to industrial/commercial, thereby limiting exposure to contamination. Because several exceedances are beneath Building 709's old foundation in the northern section of Site 27, the LUCA would also limit intrusive activities in this area.

This alternative does not require any changes to existing activities, since current land use at Site 27 is industrial. However, controls would be required to minimize exposures which could include maintenance activities in impacted areas. Notification of the Base Environmental office would be required to ensure proper instruction before invasive activities begin.

Implementability

Implementation of this alternative does not require any innovative technologies or construction activities; ongoing operations would not be interrupted. This alternative would require the Navy to control site access and to keep its use industrial/commercial. Site access can be controlled through the LUCA and/or warnings against excavation. The site would be inspected annually to ensure compliance with the LUCA. If the property was no longer under direct Navy control, development of a deed restriction would be necessary. The Navy has base planners and attorneys on staff with experience to develop and implement proper institutional controls for Site 27. The possibility of transferring Site 27 to civilian control is highly unlikely in the near future; therefore, proper controls can be implemented through planning.

The NCP requires any alternative which leaves contamination onsite to be reevaluated every 5 years to ensure its adequacy. Therefore, the institutional controls alternative would require the Navy to establish a monitoring program.

Effectiveness

Institutional controls at Site 27 would limit unacceptable excess exposure to surface soil contamination. Under current site conditions, surface soil exceeds ISCTLs at eight sample locations, six of which are exposed. This alternative would not provide any additional effectiveness for the current use scenario, but would provide long-term effectiveness by restricting future use and access. This alternative still poses some risk to site workers, because two locations exceeding ISCTLs for PAHs are exposed surface soil. However, workers would be exposed only during activities in which they contact surface soil. No risks are posed during implementation of institutional controls.

Overall, this alternative ensures that:

- Contaminants in the northern portion of Site 27 remain under concrete paving, which currently eliminates the risk pathway for site workers.
- Intrusive activities are not permitted in or near other impacted areas where concentrations exceeded ISCTLs.

This alternative does not provide more protection to site workers than the current scenario, but it does eliminate the future resident exposure pathway by excluding the property from residential use. Likely exposures will be less than the worst case assumed in SCTL development (see *Technical Report: Development of Soil Cleanup Target Levels*, ERC Hearing Draft, May 1999).

As demonstrated in the BRA, Site 27 exhibits a combined ingestion/contact pathway risk of 4.2E-06 for future site workers. This risk is on the low end of the NCP's allowable risk range of 1E-06 to 1E-04 for the industrial scenario; however, it is above FDEP's risk threshold of 1E-06.

Cost

The total present-worth cost of the institutional controls alternative is estimated at $74,400.

As shown in Table 6-8, the Navy assumes implementation of institutional controls will cost approximately $50,000, which is the estimated cost for completing the necessary documentation and annual review of site use. In addition, a 5 year reevaluation of site conditions will be required for 30 years, as per the NCP. The estimated cost for each reevaluation is $10,000 per event; assuming a 6% discount rate over 30 years, the present worth of reevaluation requirements is approximately $24,400.

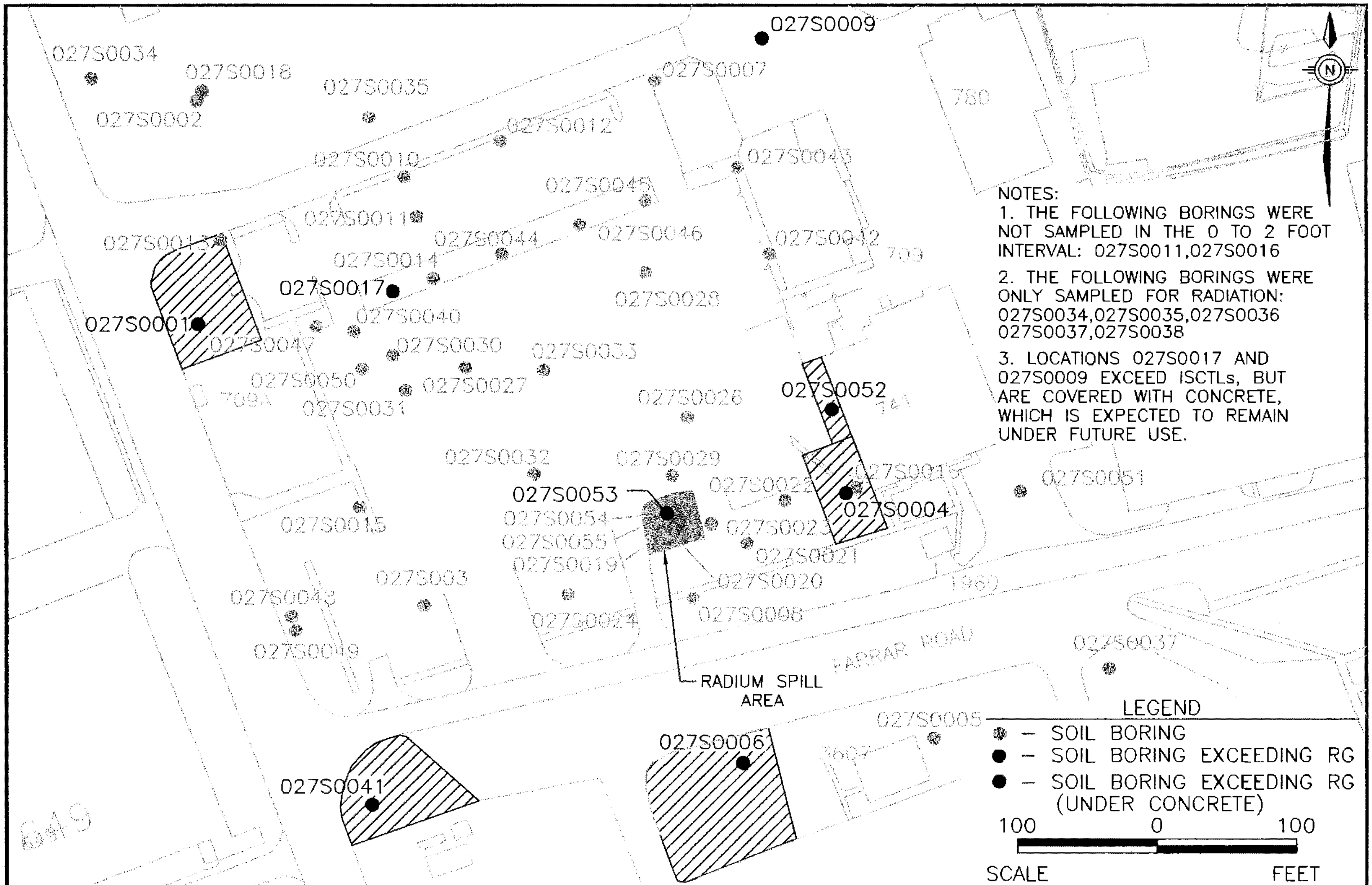
Table 6-8
Alternative 2 — Costs for Institutional Controls

Action	Quantity	Cost per Unit	Total Cost
Five Year Review	LS	$10,000	$10,000
Present value sub total at 6% discount over 30 years			$24,400
Institutional Controls (LUCA and Signs)	LS	$50,000	$50,000
Total Cost			**$74,400**

Notes:
LS = Lump sum
Cost based on review once every five years for 30 years.

6.4.3 Alternative 3: Asphalt Cap

Installing asphalt covers (as shown in Figure 6-5) would reduce the risk of site workers contacting areas of exposed contaminated soil, thus eliminating exposure pathways. Institutional controls would also be incorporated to restrict future access to contaminated soil.



DRAFT FEASIBILITY STUDY
OPERABLE UNIT 2
NAS PENSACOLA
PENSACOLA, FLORIDA

FIGURE 6–5
SITE 27
PROPOSED COVER LOCATIONS

DWG DATE: 04/22/99 | DWG NAME: 0059G014

Remedial activities for the asphalt cover would consist of:

- Implementing institutional controls (LUCA)
- Confirmatory sampling
- Site preparation
- Cover placement

Cover construction would consist of a 4- to 8-inch asphalt pavement placed over the contaminated soil areas. The pavement would be sloped to direct runoff toward open or grassy areas where percolation may occur. Confirmation sampling would help delineate the extent of soil in which contaminant concentrations exceed the RG to ensure that all contaminated soil is covered.

Implementability

Cover construction with institutional controls is technically feasible at Site 27. The site is suitable for asphalt or concrete covering to protect site workers from contaminated soil. Land use restrictions may be used to implement institutional controls. The Site 27 area that would be covered are shown in Figure 6-5; the total area to be covered is approximately 24,475 ft^2, as shown in Table 6-9. Actual areas to be covered would be determined in the field following confirmation sampling.

Table 6-9
Site 27 Areas to be Paved

Location	Estimated Pavement Dimensions	Surface Area (ft^2)
027S0001	70 ft by 70 ft	4,900
027S0004	40 ft by 65 ft	2,600
027S0006	100 ft by 90 ft	9,000
027S0041	70 ft by 100 ft	7,000
027S0052	15 ft by 65 ft	975
Total Paved Area		**24,475**

Effectiveness

Covers provide reliable protection against dermal contact and ingestion of contaminated soil. They isolate contaminants exceeding risk and guidance concentrations in environmental media, but are not designed to manage solid or hazardous waste. Confirmation sampling will ensure the entire area exceeding RGs is covered. After the cover is in place, institutional controls would help ensure continued cover effectiveness and regular maintenance would be required.

Cost

Table 6-10 presents the capital costs associated with installation of an asphalt cover and institutional controls.

Table 6-10
Alternative 3 — Costs for Asphalt Cover

Action	Quantity	Cost per Unit	Total Cost
Capital Costs for Asphalt Cover			
Mobilization/Demobilization	LS	\$500/location	\$2,000
Grading/site preparation	2,720 yd^2	\$1.50/yd^2	\$4,080
Asphalt/Concrete Surface (8" depth)	24,475 ft^2	\$1.76/ft^2	\$43,080
Engineering/Oversight	LS[1]	20% cost	\$11,290
Contingency/Miscellaneous	LS[1]	25% cost	\$14,100
Subtotal			\$74,550
Operation and Maintenance Cost			
Maintain cover (30 years)	2,720 yd^2	\$2/yd^2	\$5,440
Inspection	LS[1]	\$500	\$500
Subtotal			\$5,940
Present value at 6% discount over 30 years			\$81,230
Confirmation Sampling	16 samples (plus 2 QA/QC samples)	\$750/sample	\$13,500 [a]
Institutional Controls (LUCA and signs)		LS	\$50,000
Subtotal			\$63,500

Table 6-10
Alternative 3 — Costs for Asphalt Cover

Action	Quantity	Cost per Unit	Total Cost
Remedial Contractor Cost			$100,000
Total Cost			$319,280

Note:
LS = Lump sum
[a] = Assumes one sample will be collected along each edge of the contaminated area. Samples will be analyzed for SVOCs, pesticides/PCBs, and inorganics.

6.4.4 Alternative 4: Excavation with Offsite Disposal

This alternative involves excavating surface soil in which contaminants exceed compound-specific RGs and disposing of it offsite. Approximately 1,210 yd^3 of surface soil would be removed from the site to eliminate threats to current or future industrial site workers through dermal contact and ingestion exposure pathways. Since soil removal is based on meeting ISCTLs, institutional controls (the LUCA) will be used to ensure that future use remains industrial. Proposed removal areas are shown in Figure 6-5.

Because soil PAH concentrations are relatively low (1 to 10 part-per-million range), Site 27 soil is not expected to be considered hazardous waste. Remedial activities would consist of:

- Implement institutional controls (LUCA)
- Excavation
- Confirmatory sampling
- Backfill
- Transport of excavated material offsite
- Landfill at a Subtitle D facility

Confirmation samples would be collected from surface soil surrounding the excavation to ensure complete removal of surface soil in which contaminant concentrations exceed RGs.

After the contaminated soil is removed, clean backfill would be placed in the excavated areas and graded. TCLP analysis would be conducted to determine if the excavated soil exhibits toxicity characteristics.

Implementability

This alternative is both technically and administratively feasible at Site 27. Excavation is performed frequently and is a reliable method to remove contaminated soil within given boundaries. No technology-specific regulations apply to excavation and offsite disposal (i.e., landfilling) alternatives. Except for implementing land use restrictions, no long-term maintenance or monitoring would be required after soil in which contaminant concentrations exceed RGs has been removed. Based on groundwater elevation data presented in the RI report, groundwater is not expected to pose a problem during excavation.

Administrative considerations would include:

- Transportation and disposal of contaminated soil must adhere to USDOT regulations and requirements.
- Scheduling would be required to reduce costs for roll-off boxes and downtime while transporting the soil from Site 27 to the disposal facility.
- Daily operations at the surrounding activities will likely be interrupted short term by access problems during the removal process.

No capacity limitations are expected at the landfill, given low projected soil volumes.

Effectiveness

Excavation with offsite disposal would protect the environment at Site 27 by reducing the amount of soil in which contaminant concentrations exceed RGs.

Short-term inhalation, ingestion, and contact risks to site workers (excavation crew) would temporarily increase during excavation but should last only until remedial actions are complete. Onsite actions will require health and safety practices consistent with PAH contamination and dust generation. These risks will be reduced through proper use of PPE and engineering controls. Because no residential areas are adjacent to Site 27, there are no short-term risks to the surrounding community. No onsite long-term risks are associated with this alternative because exposed soil in which contaminants exceed the FDEP ISCTL would be removed.

Cost

Table 6-11 presents the capital costs associated with excavation and offsite disposal at a Subtitle D facility.

Table 6-11
Alternative 5 — Costs for Excavation and Offsite Disposal

Action	Quantity	Cost per Unit	Total Cost
Excavation	1,210 CY	$20/CY	$6600
Confirmation Sampling	20 samples (plus 3 QA/QC samples)	$750/sample	$17,250 [a]
Backfill	1,570 CY	$15/CY	$23,550 [b]
Subtotal			$14,300
Subtitle D Disposal Facility			

Action	Quantity	Cost per Unit	Total Cost
Transportation	79 trucks (assuming 20 yd^3 each) hauling 30 miles	$3.50/loaded mile	$8,300 [a]
Soil Disposal	1,820 tons	$36/ton	$65,500 [c]
Engineering/Oversight	LS	20% cost	$14,760
Contingency/Miscellaneous	LS	25% cost	$18,450
Subtotal			$107,010
Institutional Controls (LUCA and signs)			$50,000
Remedial Contractor Cost			$100,000
Total			$271,310

Notes:
LS = Lump sum
[a] = Four samples will be collected around each contaminated boring. Samples will be analyzed for SVOCs, pesticides/PCBs, and inorganics.
[b] = Assumes 30% fluff after excavation.
[c] = Assumes 1.5 tons per cubic yard.

6.5 Site 27 Detailed Analysis of Soil Alternatives

The following alternatives have been retained for Site 27 soil:

Soil Alternatives

Alternative 1: No Action

Alternative 2: Institutional Controls

Alternative 3: Asphalt Cover

Alternative 4: Excavation and Offsite Disposal

Each alternative is evaluated according to the nine criteria discussed in the Section 2. Criteria have been divided into the three categories — threshold, balancing, and modifying.

6.5.1 Alternative 1: No Action

The no-action alternative for Site 27 involves no active remedial effort. No actions will be taken to contain, remove, or treat soil contamination above RGs. Soil will remain in place. No engineering or institutional controls will be implemented. The No-action alternative provides a baseline against which other alternatives can be compared.

No Action: Threshold Criteria

Overall Protection of Human Health and the Environment: The no-action alternative provides no additional protection of human health and the environment. This alternative assumes that future use is residential. Site 27 soil exceeds RSCTLs at 24 locations. These exceedances would remain onsite, unmitigated. Under an uncontrolled use scenario, the BRA calculated site risks to be 2.5E-5 (residential exposure).

Compliance with ARARs: Alternative 1 does not comply with the RGs developed for Site 27; moreover, contaminants will pose risk under an uncontrolled future use scenario. Florida Proposed Rule 62-777 is a potential ARAR for OU 2. No location- or action-specific ARARs are triggered by the no-action alternative.

No Action: Balancing Criteria

The primary balancing criteria are the technical criteria on which the detailed analysis is based.

Long-term Effectiveness and Permanence: Long-term effectiveness of the no-action alternative is minimal. Soil volumes and concentrations would remain unchanged. In addition, the no action alternative does not reduce the magnitude of residual risk and lacks treatment actions that would provide permanence.

Any controls currently in place at the site — military security and limited access to/ use of the site — would remain. If use were unrestricted, no controls would be in place to protect potential receptor groups (i.e., residents).

Reduction of Toxicity, Mobility, or Volume Through Treatment: This alternative would not reduce soil contaminant mobility, toxicity, or volume. Contaminants would remain untreated and in place.

Short-Term Effectiveness: Short-term effectiveness assesses an alternative's effect on human health and the environment while it is being implemented. There are no such effects resulting from the no-action alternative

Implementability: The No-action alternative is technically feasible and easily implemented. No construction, operation, or reliability issues are associated with this alternative. Current access controls — including military security and limited personnel access to the site — have historically been reliable. No administrative coordination, offsite services, materials, specialists, or innovative technologies are required. There are no implementation risks associated with Alternative 1.

Cost: Costs include a site review and report preparation every five years for 30 years. Each review and report are estimated to cost $10,000, with a present-worth of $24,400 for the 30-year period.

No Action: Modifying Criteria

The modifying criteria are assessed formally after the public-comment period. However, the criteria are factored into identifying the preferred alternatives, as far as they are known.

State/Support Agency Acceptance: FDEP and the USEPA will have the opportunity to review and comment on this FS.

Community Acceptance: These criteria are generally not completed until after public comments on the RI/FS report and the proposed plan are received.

6.5.2 Alternative 2: Institutional Controls

The institutional controls alternative for Site 27 involves no active remedial effort. No actions will be taken to contain, remove, or treat soil contamination above RGs. Soil would remain in place and institutional controls would be incorporated into the LUCA to ensure Site 27 remains an industrial use area.

Institutional Controls: Threshold Criteria

Overall Protection of Human Health and the Environment: The institutional controls alternative provides additional protection of human health and the environment by reducing the potential for uncontrolled site access. By restricting use to industrial/commercial, future risks from residential ingestion of or contact with soil are eliminated. However, soil contamination at Site 27 exceeds industrial RGs and poses a threat under a future worker scenario. The BRA calculated a risk of 4.2E-06 for site workers under an industrial use scenario.

Compliance with ARARs: Alternative 2 does not comply with the RGs established for Site 27; Florida Proposed Rule 62-777 is a potential ARAR. No location- or action-specific ARARs are triggered by the institutional controls alternative. Contaminated soil would remain above the RGs.

Institutional Controls: Balancing Criteria

The primary balancing criteria are the technical criteria on which the detailed analysis is based.

Long-Term Effectiveness and Permanence: The long-term effectiveness of institutional controls is limited to the ability to control access to contaminated soil. Soil volumes and concentrations would remain unchanged. This alternative lacks treatment actions that would provide permanence.

Reduction of Toxicity, Mobility, or Volume Through Treatment: The institutional controls alternative would not reduce the mobility, toxicity, or volume of soil contaminants. Contaminants would remain untreated and in place onsite.

Short-Term Effectiveness: Short-term effectiveness assesses an alternative's effect on human health and the environment while it is being implemented. There are no short-term effects resulting from the institutional controls alternative.

Implementability: The institutional controls alternative is technically feasible and easily implemented. No construction issues are associated with this alternative. Current access controls — including military security and limited personnel access to the site — have historically been reliable and will be supplemented through land use restrictions. Administrative coordination is required to implement institutional controls, but no offsite services, materials, specialists, or innovative technologies would be required. There are no implementation risks with Alternative 2.

Cost: Costs associated with institutional controls include soil monitoring and report preparation every five years for 30 years, plus the cost of establishing the institutional controls. Each sampling and reporting event is estimated to cost $10,000, with a present worth of $24,400 for the 30-year period. Providing the necessary institutional controls is estimated to be a one-time cost of $50,000, for a total cost of $74,400.

Institutional Controls: Modifying Criteria

The modifying criteria are assessed formally after the public-comment period. However, the criteria are factored into identifying the preferred alternatives, as far as they are known.

State/Support Agency Acceptance: FDEP and the USEPA will have the opportunity to review and comment on this FS.

Community Acceptance: These criteria are generally not completed until after public comments on the RI/FS report and the proposed plan are received.

6.5.3 Alternative 3: Asphalt Cover

This alternative uses a physical barrier to cover the two exposed locations where contaminants exceed RGs. In conjunction with the cover alternative, land use will be restricted to industrial to minimize uncontrolled exposure and prevent cover disturbance.

Asphalt Cover: Threshold Criteria

Overall Protection of Human Health and the Environment: The asphalt cover would eliminate the threat of dermal and ingestive contact for current and future site workers. Contaminated soil would be left onsite indefinitely and the cover maintained to ensure adequate protection.

This alternative would protect human health and the environment by physically eliminating receptor pathways and controlling access through land use restrictions. Cover construction and maintenance would be easily implemented and current site controls (site security, access control, and fencing) and the LUCA would be adequate to ensure minimal disturbance. Short-term risks during implementation from inhalation and dermal contact would be minimal, and could be controlled using common engineering techniques and use of PPE.

Compliance with ARARs: The asphalt cover with associated institutional controls would comply with RGs for future industrial workers. The potential for contact with soil in which contaminants exceed ISCTLs is eliminated by removing the primary pathways.

The cover would isolate or eliminate contaminants exceeding RGs in environmental media, but not manage solid or hazardous waste. Site grading would need to comply with federal, state, and local air emissions and storm water control regulations. Remedial actions within Site 27 may trigger the following ARARs:

- Flood plain requirements as outlined in the *National Environmental Policy Act* (40 CFR Part 6 Appendix A), *Fish and Wildlife Coordination Act* (40 CFR 6.302).

- Storm water discharge requirements as outlined in the *Clean Water Act* (40 CFR 122, 125, 129, 136) and the *Florida Storm Water Discharge Regulations* (FAC 62-25).

Asphalt Cover: Balancing Criteria

Long-Term Effectiveness and Permanence: An asphalt cover would effectively reduce site worker dermal or ingestive contact with contaminated soil, and would require inspection and maintenance. Asphalt covers are generally reliable containment controls; if the asphalt degraded or was removed, repairs could be made to re-establish the cover's integrity.

This alternative eliminates residual risk to site workers by managing Site 27 as an industrial site and restricting land use. The use of these covered soil areas would be controlled institutionally.

Reduction of Toxicity, Mobility, or Volume Through Treatment: Constructing an asphalt cover at Site 27 would not remove, treat, or remediate the contaminated soil; it provides containment only. The cover is considered reversible, because contaminants exceeding RGs under the cover would remain onsite; if the cover fails because of poor maintenance, contaminants may be exposed. This alternative would not reduce toxicity, mobility, or volume through treatment, nor would it satisfy the statutory preference for treatment.

Short-Term Effectiveness: Adverse impacts to the surrounding environment are not anticipated during cover construction; engineering controls would be applied to manage storm water runoff and siltation. Once design plans are approved, actual cover construction would be expected to take less than one month. During construction, workers would be at risk for dermal or ingestive contact with site contaminants; however, this risk would be reduced by proper removal practices and use of PPE.

Implementability: An asphalt cover with institutional controls and limited excavation is technically and administratively feasible. This alternative could be readily applied at the site, because the proposed areas to be covered are easily accessible. Current access controls have been reliable and will be supplemented through the LUCA, and thus implementing this alternative would merely involve placement of the cover and implementation of the LUCA. Future monitoring and maintenance would involve periodic visual inspection and repairing any damage or degradation. Repairs are easily implemented, and asphalt covering would not require any extraordinary services or materials. It is possible that radium contamination and PAH contamination overlap; a radiological sampling event should be performed before any active Site 27 remedy is implemented, to better define the extent of radium contamination. All sampling and remediation activities should be coordinated with RASO.

Cost: Costs for this alternative are detailed in Section 6.5.3. The total cost for Alternative 3 including the cover, institutional controls, excavation, and the corrective action contractor is $319,280 (net present value). O&M costs comprise approximately 25% of the net present value.

Asphalt Cover: Modifying Criteria

State/Support Agency Acceptance: FDEP and the USEPA will have the opportunity to review and comment on this FS.

Community Acceptance: These criteria are generally not completed until after public comments on the RI/FS report and the proposed plan are received.

6.5.4 Alternative 4: Excavation and Offsite Disposal

The primary element of this alternative is the excavation of soil contaminated above RGs from the site and disposal in an approved landfill. Land use is restricted to industrial to minimize uncontrolled exposure.

Excavation and Offsite Disposal: Threshold Criteria

Overall Protection of Human Health and the Environment: Excavation and offsite disposal protects human health and the environment by removing contaminated soil posing a risk above RGs. Risk to human health and the environment from contaminants exceeding ISCTLs would be eliminated. Short-term risks during implementation from inhalation and dermal contact would be minimal, and could be controlled with common engineering techniques and use of PPE. The alternative could be easily implemented and would protect current and future site workers and the environment.

Compliance with ARARs: Excavation would meet chemical-specific ARARs for the associated RGs which protect future industrial site workers. Possible location- and action-specific ARARs include:

- Floodplain requirements as outlined in the *National Environmental Policy Act* (40 CFR Part 6 Appendix A), *Fish and Wildlife Coordination Act* (40 CFR 6.302).

- Storm water discharge requirements as outlined in the *Clean Water Act* (40 CFR 122, 125, 129, 136) and the *Florida Storm Water Discharge Regulations* (FAC 62-25).

- USDOT transportation requirements.

- Solid waste disposal requirements (soil is not expected to exhibit hazardous waste characteristics).

Cross-contamination with radium-contaminated soil would trigger mixed waste rules and associated requirements for disposal of radiological waste.

Excavation and Offsite Disposal: Balancing Criteria

Long-Term Effectiveness and Permanence: The excavation alternative would remove the contaminated soil from the site and dispose of it in a permitted Subtitle D facility. This alternative would eliminate risk from contaminants exceeding RGs. Soil remaining onsite would not threaten human health under an industrial use scenario. The LUCA will effectively control future land use.

Excavation with disposal in an offsite landfill is a particularly reliable option, because soil removal from the site would eliminate risks exceeding RGs. Some future liability might be incurred through disposal at a landfill.

Reduction of Toxicity, Mobility, or Volume Through Treatment: The excavation with disposal at an offsite landfill alternative would not satisfy the preference for treatment. Although it is anticipated that excavated soil is non-hazardous, TCLP analysis will be performed for verification.

Excavation would eliminate the source area and therefore, the contaminants exceeding RGs. This alternative includes the removal of approximately 1,210 CY of soil from the site which would be isolated in a secure landfill. Because the source would no longer remain onsite, excavation is considered permanent. Mobility, toxicity and volume would not be reduced and the preference for treatment would not be satisfied.

Short-Term Effectiveness: Excavation would be sufficiently removed from the public to reduce health and safety concerns associated with soil removal. Excavation workers would be exposed to increased particulate emissions and might also have more dermal contact with hazardous constituents. However, worker risks can be reduced with dust control technologies and a site-specific health and safety plan that specifies PPE, respiratory protection, etc. The health and safety plan should also address the presence of radiological contamination at Site 27 and the possibility of cross-contamination.

Implementability: Excavation with offsite landfilling is technically and administratively feasible at Site 27. Removal and offsite disposal have been commonly applied at previous sites. The only potential technical problems that might slow down removal activities are materials handling and disposal (standby time between confirmatory sampling and disposal). Landfill debris, if present within the 0- to 2-foot interval, may require disposal at a debris landfill. Areas to be excavated are readily accessible, and no future remedial actions would be required after this alternative is completed. It is possible that radium contamination and PAH contamination overlap; a radiological sampling event should be performed before any active Site 27 remedy is implemented, to better define the extent of radium contamination. All sampling and remediation activities should be coordinated with RASO.

This alternative would not require any extraordinary services or materials.

Cost: Detailed costs associated with Alternative 4 are presented in Section 6.5.4. Total direct costs for excavation and disposal at a Subtitle D facility are estimated to be $271,310. No

O&M costs are associated with this alternative. Costs could increase significantly if cross-contamination with radium-contaminated soil occurs.

Excavation and Offsite Disposal: Modifying Criteria

State/Support Agency Acceptance: FDEP and the USEPA will have the opportunity to review and comment on this FS.

Community Acceptance: These criteria are generally not completed until after public comments on the RI/FS report and the proposed plan are received.

6.6 Site 27 Comparative Analysis of Alternatives

The Site 27 comparative analysis of alternatives is presented in Table 6-12.

Table 6-12
Comparative Analysis of Site 27 Soil Alternatives

Evaluation Criteria	Alternative 1: No action	Alternative 2: Institutional Controls	Alternative 3: Asphalt Cover	Alternative 4: Excavation and Offsite Disposal
Threshold Criteria				
Protection of human health and the environment (HH&E)	No action is implemented. Because the site's future use is uncontrolled and site contaminants exceed residential standards, there is potential risk to future site residents.	Institutional controls are implemented to restrict land use and therefore minimize uncontrolled exposures. Because locations exceed industrial standards, there is potential risk to current and future site workers.	Asphalt cover will eliminate the dermal contact and ingestion pathway; the LUCA will limit site use to industrial, thus minimizing uncontrolled exposures.	Offsite disposal is a highly effective and reliable way to eliminate risk above RGs. Removal of contaminanted medial from the site is protective of current and future site workers.
Compliance with ARARs	Current conditions do not meet RGs. While risk is within USEPA's acceptable risk range, onsite risks exceed FDEP's threshold criteria of 1E-06.	Current conditions do not meet RGs. While risk is within USEPA's acceptable risk range, onsite risks exceed FDEP's threshold criteria of 1E-06.	Asphalt cover will eliminate surface soil pathways, and therefore meet RGs. Actions would require compliance with storm water and floodplain requirements.	Removal would comply with RGs, and all actions would require compliance with storm water and floodplain requirements.
Balancing Factors				
Long-term effectiveness and permanence	None.	Institutional controls are effective at limiting access. The LUCA will need to be maintained.	Covers are effective at eliminating the risk pathway. Maintenance will be required to ensure effectiveness.	Excavation and offsite disposal eliminates risk onsite. The LUCA will restrict land use to industrial and eliminate unrestricted exposures.
Reduction of Toxicity, Mobility, or Volume through Treatment	None.	None.	None.	None.
Short-Term Effectiveness	No risks are associated with the no action alternative.	No risks are associated with institutional controls.	Implementing the remedy will require less than 1 month; short-term exposures may be reduced by engineering controls and PPE.	Implementing the remedy will require less than 1 month; short- term exposures may be reduced by engineering controls and PPE.
Implementability	Technically and administratively feasible. Easily implemented.	Technically and administratively feasible. Easily implemented.	Technically and administratively feasible. Easily implemented.	Technically and administratively feasible. Easily implemented.
Cost	**Capital: none** **Annual: $10,000, every 5 years** **PW: $24,000**	**Capital: $50,000** **Annual: $10,000, every 5 years** **PW: $74,000**	**Capital: $238,050** **Annual: $5,940** **PW: $319,280**	**Capital: $271,310** **Annual: $0** **PW: $271,310**

Table 6-12
Comparative Analysis of Site 27 Soil Alternatives

Evaluation Criteria	Alternative 1: No action	Alternative 2: Institutional Controls	Alternative 3: Asphalt Cover	Alternative 4: Excavation and Offsite Disposal
Modifying Criteria				
State/Support Agency Acceptance	FDEP and USEPA will have opportunity to review and comment on this technology.	FDEP and USEPA will have opportunity to review and comment on this technology.	FDEP and USEPA will have opportunity to review and comment on this technology.	FDEP and USEPA will have opportunity to review and comment on this technology.
Community Acceptance	Community acceptance will be established after the public comment period.	Community acceptance will be established after the public comment period.	Community acceptance will be established after the public comment period.	Community acceptance will be established after the public comment period.

7.0 SITE 30 SOIL FEASABILITY EVALUATION

7.1 Site Description and History

This approximately 35-acre site houses the Building 649 complex, industrial buildings where NADEP carried out various functions related to aircraft component repair. Operations within this complex began in the 1940s and continued until NADEP closed. Site 30 also includes Buildings 3220 and 3450, former NADEP buildings where aircraft electronics were repaired, and a portion of the former IWTP sewer line. The portions of the sewer investigated with Site 30 include those associated with Sites 25, 27, and 30 and downstream segments. These include the segment extending from the Building 649 complex, the feeder line from Building 3220, and the main line running to the former IWTP.

In August 1994 PWC excavated, cleaned, and disposed of a waste-receiving structure and its contents located in Wetland 5A south of Site 30. The contents were contained in 55-gallon drums and the structure was pressure washed and returned for salvage to the DRMO. A surface water sample collected after removal of the structure did not detect concentrations which exceeded Florida Surface Water Standards. Two sediment samples were collected after the removal of the structure. Both sediment samples exceeded several Florida Sediment Quality Assessment Guidelines for a variety of constituents, including inorganics, pesticides/PCBs, and SVOCs. Risk from the residual contamination in Wetland 5A was evaluated during the Remedial Investigation for Site 41.

7.1.1 Site 30 Surface Soil Comparison with RSCTLs

Eleven out of 58 locations at Site 30 exceeded one or more RSCTLs, as shown in Table 7-1. Samples were collected from multiple intervals in the top 2 feet of soil. These intervals may be designated as -00, -01, or -02 Primary contaminants included arsenic, chromium, PCBs, and PAHs.

Note that boring 030S0147 exceeds the RSCTL for arsenic, but this location cannot be identified. Though it will be listed in the text, it will not be shown on associated figures.

If the extent of contamination is assumed to be limited to a 100- by 100-foot area around each sample point, to a depth of 2 feet, then a total of 8,900 CY of surface soil are impacted above RSCTLs in the Site 30 area.

Table 7-1
Site 30 Surface Soil Locations Exceeding RSCTLs

Location	Contaminant	Concentration (in mg/kg)
030-S-0012-02	Benzo(a)pyrene	0.17 J
030-S-0020-02	Benzo(a)pyrene	0.22 J
030-S-0102-01	Arsenic	1.5 J
	Benzo(a)anthracene	1.7
	Benzo(a)pyrene	0.19 J
	Benzo(b)fluoranthene	2
	Dibenz(a,h)anthracene	0.58 J
030-S-0102-02	Benzo(a)pyrene	1.9
030-S-0103-01	Arsenic	1.8 J
030-S-0106-01	Arsenic	0.82 J
030-S-0116-01	Benzo(a)pyrene	[illegible]
030-S-0125-01	Chromium	395 J
030-S-0137-01	Arsenic	4.7
	Benzo(a)anthracene	2.5 J
	Benzo(a)pyrene	5
	Benzo(b)fluoranthene	4.6
	Dibenz(a,h)anthracene	2.1 J
	Indeno(1,2,3-cd)pyrene	5.6
030-S-0138-01	Aroclor 1242	10 DJ
	Aroclor 1254	1.8 DJ
	Aroclor 1260	0.580 J
030-S-0140-01	Arsenic	1.5 J
	Benzo(a)anthracene	22
	Benzo(a)pyrene	18
	Benzo(b)fluoranthene	16
	Benzo(k)fluoranthene	21
	Dibenz(a,h)anthracene	5.9 J
	Indeno(1,2,3-cd)pyrene	13

Table 7-1
Site 30 Surface Soil Locations Exceeding RSCTLs

Location	Contaminant	Concentration (in mg/kg)
030-S-0147-01	Arsenic	4.8
030-S-0151-01	Arsenic	3.6 J

Notes:
RSCTLs may be found in Appendix C.
J = Concentration is estimated.
D = Concentration was obtained from a diluted sample.
mg/kg = milligrams per kilogram

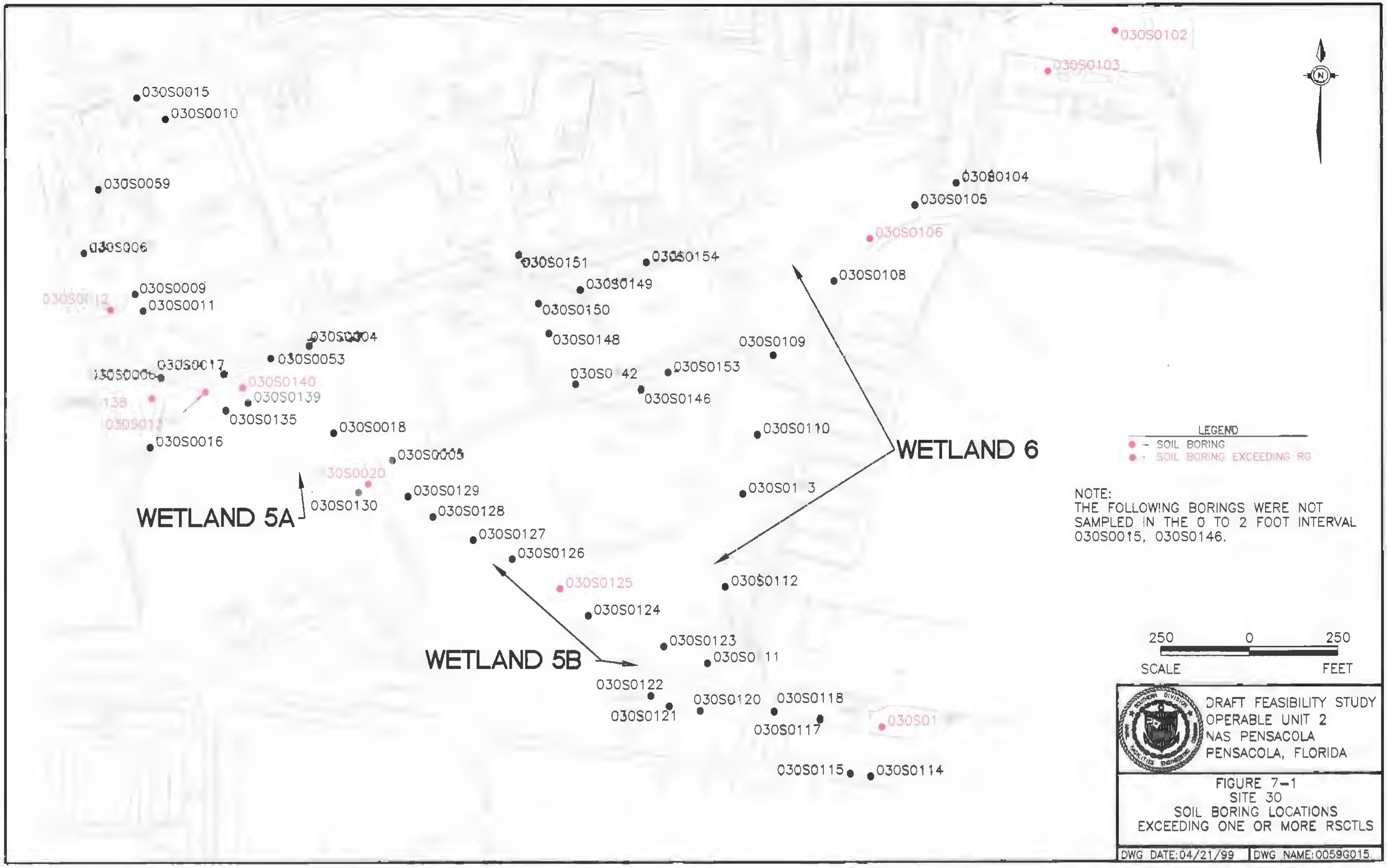
Because Site 30 is large, contaminant locations are discussed spatially below; exceedances are shown on Figure 7-1.

- Borings 030-S-0137, 030-S-0138, and 030-S-0140 extend linearly east to west, south of Building 755. 030-S-0137 and -0140, characterized particuarly by PAH contamination, are immediately south of a paved roadway accessing Buildings 2691, 3833, and 755. Boring 030-S-0138, on a grassy median in front of Building 2691, is characterized exclusively by PCBs.

- Boring 030-S-0102-01 is immediately south of Building 693, and is characterized primarily by PAH contamination.

- Boring 030-S-151 is immediately southwest of Building 225, and exhibits only arsenic contamination at roughly twice the RC.

- Borings 030-G-S020, 030-S-0116, and 030-S-0125, in the southern portion of the site along the former industrial sewer, are characterized by PAHs (-0020 and -0116) and chromium (-0125). Contaminants found at intervening sample locations did not exhibit concentrations above RSCTLs, suggesting a discontinuous source.


030S0102
030S0103
030S0015
030S0010
030S0059
030S0104
030S0105
030S0106
030S0151
030S0154
030S0149
030S0108
030S0009
030S0011
030S0150
030S0148
030S0109
030S0053
030S0017
030S0140
030S0139
030S0135
030S0153
030S0146
030S0018
030S0016
030S0110
WETLAND 6
LEGEND
SOIL BORING
SOIL BORING EXCEEDING RG
30S0020
030S0129
030S0130
WETLAND 5A
030S0128
030S0127
030S0126
NOTE:
THE FOLLOWING BORINGS WERE NOT SAMPLED IN THE 0 TO 2 FOOT INTERVAL 030S0015, 030S0146.
030S0125
030S0112
030S0124
030S0123
WETLAND 5B
250
0
250
SCALE
FEET
030S0122
030S0120
030S0118
030S0121
030S0117
030S0115
030S0114
DRAFT FEASIBILITY STUDY
OPERABLE UNIT 2
NAS PENSACOLA
PENSACOLA, FLORIDA
FIGURE 7-1
SITE 30
SOIL BORING LOCATIONS
EXCEEDING ONE OR MORE RSCTLS
DWG DATE:04/21/99
DWG NAME:0059G015

- Locations 030-S-0102, 030-S-0103, and 030-S-0106, in the northeastern portion of the site along the former industrial sewer, are characterized by PAHs in -0102 and arsenic in the other two borings. The arsenic concentration in 030-S-0106 is below the NAS Pensacola RC. Contaminants differ between borings 030-S-0102 and -0103, and there are no intervening borings to confirm contamination.

7.1.2 Site 30 surface Soil Comparison with ISCTLs

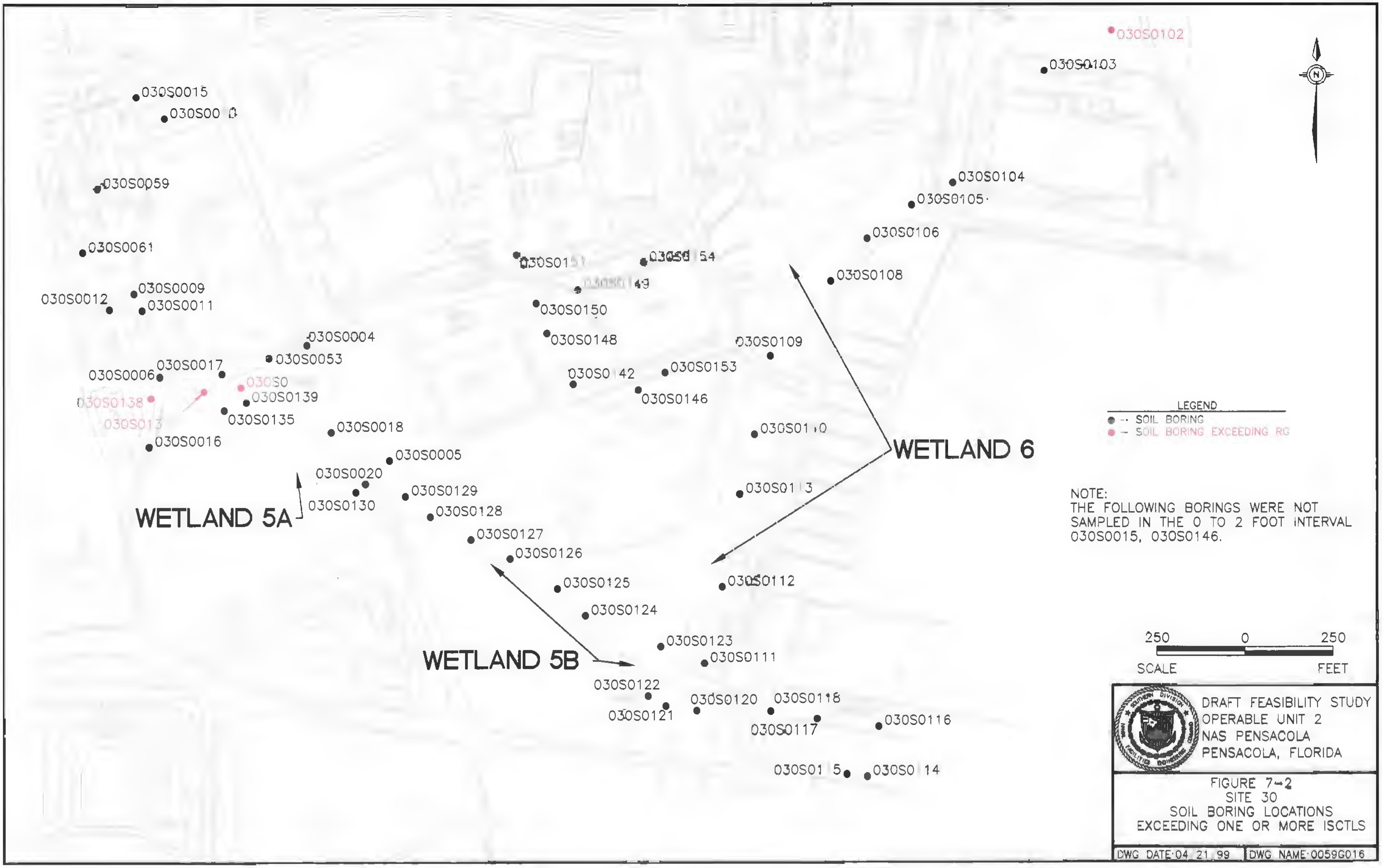
Contaminants at five locations exceeded ISCTLs, including arsenic, PCBs, and PAHs, as shown in Table 7-2.

Because Site 30 is large contaminant locations are discussed spatially below. exceedances are shown on Figure 7-2

- Borings 030-S-0137, 030-S-0138, and 030-S-0140 extend linearly east to west south of Building 755 030-S-0137 and -0140, characterized particuarly by PAH contamination, are immediately south of a paved roadway accessing Buildings 2691, 3833, and 755 Boring 030-S-0138, on a grassy median in front of Building 2691, is characterized exclusively by PCBs.

- Boring 030-S-0102-01, immediately south of Building 693, is characterized primarily by PAH contamination.

If the extent of contamination is assumed to be limited to a 100 by 100 foot area around each sample point, to a depth of 2 feet bgs, then a total of 3,700 CY of surface soil are impacted above ISCTLs in the Site 30 area.



DRAFT FEASIBILITY STUDY
OPERABLE UNIT 2
NAS PENSACOLA
PENSACOLA, FLORIDA

FIGURE 7-2
SITE 30
SOIL BORING LOCATIONS
EXCEEDING ONE OR MORE ISCTLS

DWG DATE: 04/21/99 | DWG NAME: 0059G016

Table 7-2
Site 30 Surface Soil Locations Exceeding ISCTLs

Location	Contaminant	Concentration (in mg/kg)
030-S-0102-02	Benzo(a)pyrene	1.9
	Dibenz(a,h)anthracene	0.58 J
030-S-0137-01	Arsenic	4.7
	Benzo(a)pyrene	5
	Dibenz(a,h)anthracene	2.1 J
	Indeno(1,2,3-cd)pyrene	5.6
030-S-0138-01	Aroclor-1242	10 DJ
030-S-0140-01	Benzo(a)anthracene	22
	Benzo(a)pyrene	18
	Benzo(b)fluoranthene	16
	Dibenz(a,h)anthracene	5.9 J
	Indeno(1,2,3-cd)pyrene	13
030-S-0147-01	Arsenic	4.8

Notes:
ISCTLs may be found in Appendix C
J = Concentration is estimated.
D = Concentration was obtained from a diluted sample.
mg/kg = milligram per kilogram

7.1.3 Site 30 Comparison with Leaching Values Protective of Groundwater

SL-PQGs were evaluated with respect to a poor quality aquifer; exceedances are shown in Table 7-3. Dieldrin was detected in soil above its SL-PQG at two locations, and chromium at one location. The dieldrin exceedances were detected at discontinuous locations (i.e., surrounding samples did not indicate dieldrin at leachable concentrations) as shown in Figure 7-3; 030-S-127 is along the former industrial sewer, and 030-S-154 is on the north side of the site along Farrar Road. These data suggest that the dieldrin detections above the SL-PQG are isolated and there is no large dieldrin source area. Moreover, dieldrin was not quantified in groundwater at concentrations exceeding GW-PQG criteria. Therefore, risks posed by soil leachability to groundwater are considered minimal; dieldrin contaminated soil will not be considered during remedial actions.

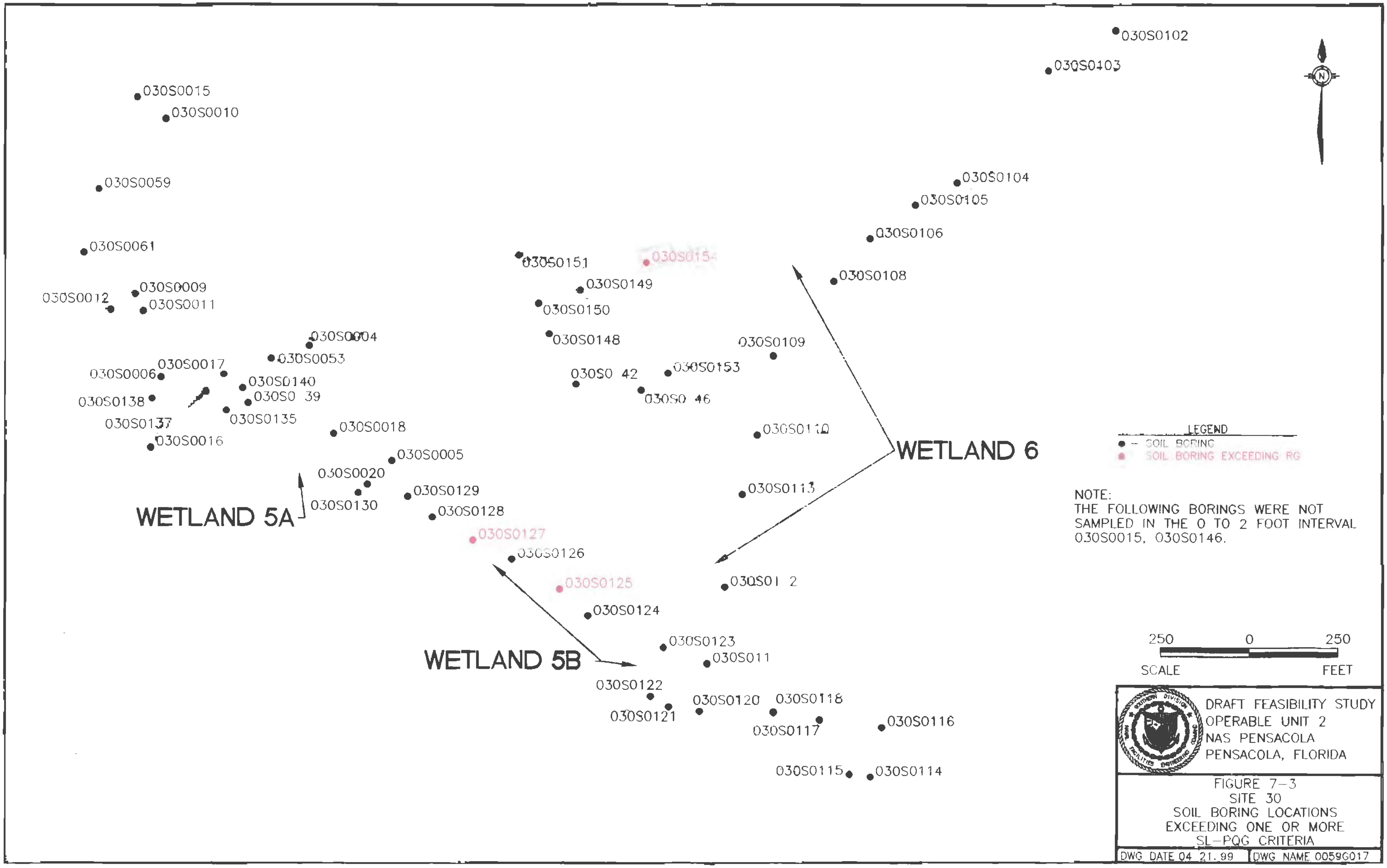

030S0102
030S0103
030S0015
030S0010
030S0059
030S0104
030S0105
030S0106
030S0061
030S0151
030S0149
030S0108
030S0012
030S0009
030S0011
030S0150
030S0004
030S0148
030S0109
030S0053
030S0017
030S0006
030S0140
030S0153
030S0138
030S0135
030S0137
030S0016
030S0018
030S0110
030S0005
WETLAND 6
030S0020
030S0129
030S0113
WETLAND 5A
030S0130
030S0128
030S0127
030S0126
030S0125
030S0124
WETLAND 5B
030S0123
030S0122
030S0120
030S0118
030S0121
030S0117
030S0116
030S0115
030S0114
LEGEND
SOIL BORING
SOIL BORING EXCEEDING RG
NOTE:
THE FOLLOWING BORINGS WERE NOT SAMPLED IN THE 0 TO 2 FOOT INTERVAL 030S0015, 030S0146.
250 0 250
SCALE FEET
DRAFT FEASIBILITY STUDY
OPERABLE UNIT 2
NAS PENSACOLA
PENSACOLA, FLORIDA
FIGURE 7-3
SITE 30
SOIL BORING LOCATIONS
EXCEEDING ONE OR MORE
SL-PQG CRITERIA
DWG DATE 04 21 99
DWG NAME 0059G017

Table 7-3
Site 30 Locations Exceeding SL-PQGs

Location	Contaminant	Concentration (in mg/kg)
030-S-0125-01	Chromium	395 J
030-S-0127-03	Dieldrin	0.085 D
030-S-0154-02	Dieldrin	0.064 DJ

Notes:
SL-PQG criteria may be found in Appendix C.
J = Concentration is estimated.
D = Concentration is obtained from a diluted sample.
mg/kg = milligrams per kilogram.

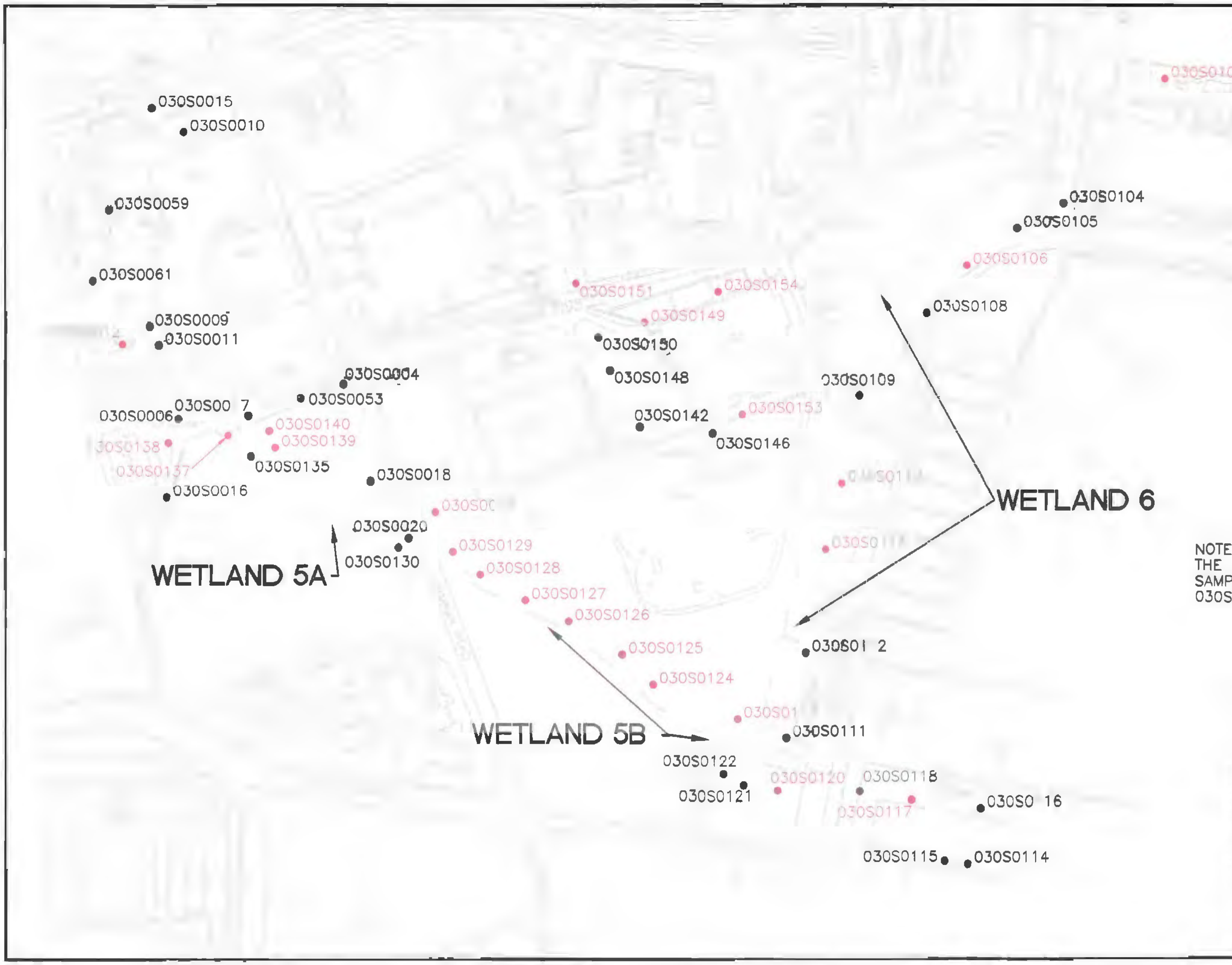
Chromium was only detected at one location, 030-S-0125; adjacent borings did not contain chromium above the SL-PQG, suggesting that no large source area exists. Chromium was detected in Site 30 groundwater at concentrations above GW-PQG criteria; however, these locations are significantly upgradient of the 030-S-0125 location; intervening soil and groundwater locations did not quantify a chromium source in soil. It is possible that the source of upgradient chromium in groundwater is historical, already attenuated at the former source area; conversely, it is possible that, due to the data density used to delineate contamination in the RI, the chromium source was never identified. Chromium has been identified as a groundwater contaminant of concern in Section 9 because of concentrations near the Building 649 complex. Empirical data indicate, however, chromium is not present above target cleanup levels in groundwater along the former sewer; as a result the exceedance at 030-S-0125 may be considered anomalous. Therefore, chromium contaminated soil in excess of the SL-PQG will not be considered during remedial actions.

7.1.4 Site 30 Comparison with Leaching Values Protective of Water Bodies

Several contaminants were detected in site soil at concentrations above freshwater SL-SW criteria, as shown in Table 7-4 and Figure 7-4. These compounds include: Aroclor 1242, Aroclor 1254, dieldrin, various PAHs, bis(2-ethylhexyl)phthalate, phenol, and 1,2-dichloroethane. However, of these compounds, only dieldrin, bis(2-ethylhexyl)phthalate, phenol, and 1,2-dichloroethane were detected in groundwater, indicating that the remaining compounds were not leaching appreciably to groundwater.

Dieldrin was detected in multiple soil borings across the site above its SL-SW. In groundwater, however, dieldrin was detected in only one well at Site 30, intermediate depth well 030-GI-06, at a concentration slightly above the surface water criteria. Dieldrin was not detected in any shallow groundwater monitoring wells, suggesting that this compound is not leaching to groundwater. The single exceedance in 030-GI-06 may be attributable to drilling carrydown or may otherwise be an installation artifact The absence of dieldrin from groundwater indicates it is not a threat to surface water

Bis(2-ethylhexyl)phthalate was detected in one soil boring, 030-S-0012, above its SL-SW at a depth of 20 feet bgs. Bis(2-ethylhexyl)phthalate was detected in several monitoring wells at Site 30 at concentrations exceeding surface water criteria. However, none of these wells is immediately adjacent to boring 030-S-0012, suggesting that the boring is not a source for this compound. Rather, bis(2-ethylhexyl)phthalate is a common laboratory and sampling artifact. Groundwater detections were typically less than 15 μg/L, and only slightly exceeded GS-SW criteria



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PENSACOLA, FLORIDA

FIGURE 7–4
SITE 30
SOIL BORING LOCATIONS
EXCEEDING ONE OR MORE
SL–SW CRITERIA

DWG DATE 04 21 99 | DWG NAME:0059G018

Table 7-4
Site 30 Locations Exceeding SL-SWs (in mg/kg)

Location	Contaminant	Concentration
030-S-0005-02	Dieldrin	0.039
030-S-0012-20	bis(2-ethylhexyl)phthalate	58
030-S-0102-02	Benzo(a)anthracene	1.7
	Benzo(a)pyrene	1.9
	Benzo(b)fluoranthene	2
	Chrysene	1.6 J
030-S-0103-04	Dieldrin	0.0044 J
030-S-0106-01	Dieldrin	0.015
030-S-0110-01	Dieldrin	0.038
030-S-0113-01	Phenol	0.047 J
030-S-0117-04	Dieldrin	0.0061
030-S-0120-01	Dieldrin	0.006
030-S-0122-01	Dieldrin	0.01
030-S-0122-03	Dieldrin	0.0091
	Phenol	0.039 J
030-S-0123-01	Dieldrin	0.014
030-S-0123-04	Dieldrin	0.017
030-S-0124-01	Dieldrin	0.018
	1,2-Dichloroethane	0.021 J
030-S-0125-01	Dieldrin	0.032
	1,2-Dichloroethane	0.05 J
030-S-0125-03	Dieldrin	0.031 J
030-S-0126-06	Dieldrin	0.04
030-S-0127-01	Dieldrin	0.011
	1,2-Dichloroethane	0.045
030-S-0127-03	Dieldrin	0.085 D
	1,2-Dichlroethane	0.025
030-S-0127-05	Dieldrin	0.0072

Table 7-4
Site 30 Locations Exceeding SL-SWs (in mg/kg)

Location	Contaminant	Concentration
030-S-0128-01	Dieldrin	0.006
030-S-0129-01	Dieldrin	0.0042
030-S-0137-01	Dieldrin	0.0056 J
	Benzo(a)anthracene	2.5 J
	Benzo(a)pyrene	3
	Benzo(b)fluoranthene	4.6
	Benzo(k)fluoranthene	4.2 J
	Chrysene	2.3 J
	Indeno(1,2,3-cd)pyrene	5.6
	1,2-Dichloroethane	0.096
030-S-0138-01	Aroclor 1242	10 DJ
	Aroclor 1254	1.8 DJ
030-S-0139-01	1,2-Dichloroethane	0.033
030-S-0140-01	Benzo(a)anthracene	22
	Benzo(a)pyrene	18
	Benzo(b)fluoranthene	16
	Benzo(k)fluoranthene	21
	Chrysene	20
	Dibenz(a,h)anthracene	5.9 J
	Indeno(1,2,3-cd)pyrene	13
	1,2-Dichloroethane	0.027
030-S-0148-06	1,2-Dichloroethane	0.02
030-S-0151-01	Dieldrin	0.0059
030-S-0153-11	Dieldrin	0.0049
030-S-0154-02	Dieldrin	0.064 DJ
030-S-0154-06	Dieldrin	0.028

Notes:
SL-SW criteria may be found in Appendix C.
J = Concentration is estimated.
D = Concentration was obtained from a diluted sample.
mg/kg = milligrams per kilogram

Phenol was quantified in two borings above its SL-SW, 030-S-0113 and 030-S-0122. Though quantified in groundwater at several locations above applicable surface water quality criteria, phenol was not identified in wells adjacent to the boring locations, suggesting that phenol is not leaching from these areas at appreciable concentrations. Groundwater exceedances may be attributable to other sources or historical discharges that have since attenuated. Phenol concentrations above the SL-SW, because they cannot be correlated with adjacent groundwater data, will be regarded as anomalous and not representative of a soil source area.

1,2-Dichloroethane was identified in multiple borings at concentrations above its SL-SW, including. 030-S-0124, 030-S-0125, 030-S-0127, 030-S-0137, 030-S-0139, 030-S-0140, and 030-S-0148 However, when data from adjacent monitoring wells are reviewed, 1,2 dichloroethane was not detected above any applicable criteria. These data suggest that soil contamination defined by the SL-SW criterion is not contributing to groundwater contamination at appreciable concentrations.

A review of Wetland 5A/5B and Wetland 6 surface water data indicate that none of these contaminants were detected in surface water except bis(2-ethylhexyl)phthalate, which is a common laboratory and sampling artifact.

Dieldrin. bis(2-ethylhexyl)phthalate, phenol. and 1,2-dichloroethane were detected in 14 out of 20 sediment sampling locations at Sites 5A, 5B, and 6. Where detected, these compounds contributed minimal hazard at each individual sediment sample location compared to other contaminants present. These data suggest that Site 30 is not a primary source of wetland contamination. For more information regarding risk within the wetland complex adjacent to OU 2, the reader is referred to the Site 41 RI

7.2 Remedial Goals

RGs for OU 2 have been proposed for the protection of human health and the environment given current and future land use. OU 2 has historically been used for industrial purposes, as described in Section 1. Future risk to human health will be minimized by maintaining OU 2 as an industrial site. Institutional controls will be required for both soil and groundwater to limit exposures above appropriate criteria.

RGOs

- Protect the health of current and future site workers. ISCTLs will be used as RGs.

- Protect the environment by ensuring future soil-to-groundwater transfers are protective of a poor quality aquifer. SL-PQG criteria will be used to determine risks to the underlying aquifer.

7.2.1 Surface Soil Remediation Goals

Surface soil RGs are based on ISCTLs, as land use conditions are not expected to change. Table 7-5 presents the RGs for surface soil at Site 30; only contaminants exceeding an RG are shown in this table.

Table 7-5
Contaminant-Specific Remediation Goals for Surface Soil at Site 30

Contaminant	RG (in mg/kg)
Arsenic	3.7
Aroclor-1242	2.1
Aroclor-1260	2.1
Benzo(a)anthracene	5
Benzo(a)pyrene	0.5

Table 7-5
Contaminant-Specific Remediation Goals for Surface Soil at Site 30

Contaminant	RG (in mg/kg)
Benzo(b)fluoranthene	4.8
Dibenz(a,h)anthracene	0.5
Indeno(1,2,3-cd)pyrene	5.3

7.2.2 Subsurface Soil Remediation Goals

Based on a comparison of site analytical data with Florida SL-PQG criteria, as discussed in Sections 7.1.3 and 7.1.4, contamination detected in above SL-PQG and SL-SW criteria does not represent a current or potential source of groundwater contamination: there is no distinguishable source mass for site contaminants. Therefore, no subsurface remediation goals have been established for OU 2.

7.2.3 Soil Volumes

Table 7-6 identifies locations exceeding one or more ISCTLs. This table also identifies surface soil conditions and impacted soil volumes associated with each location.

Table 7-6
Site 30 Locations Exceeding RGs

Location	Contaminant	Concentration (in mg/kg)	Comment	Volume
030-S-0102-02	Benzo(a)pyrene Dibenz(a,h)anthracene	1.9 0.58 J	Exposed surface soil.	Impacted area assumed to be 100 ft by 100 ft by 2 ft. Total volume 740 CY.
030-S-0137-01	Arsenic Benzo(a)pyrene Dibenz(a,h)anthracene Indeno(1,2,3-cd)pyrene	4.7 5 2.1 J 5.6	Exposed surface soil.	Impacted area for 030S0137 and 030S140 is 75 ft by 300 ft by 2 ft. Total volume 1,670 CY.
030-S-0138-01	Aroclor 1242	10 DJ	Exposed surface soil.	Impacted area triangular 90 ft by 50 ft. Total volume 167 CY.

Table 7-6
Site 30 Locations Exceeding RGs

Location	Contaminant	Concentration (in mg/kg)	Comment	Volume
030-S-0140-01	Benzo(a)anthracene	22	Exposed surface soil.	Impacted area for 030S0137 and 030S140 is 75 ft by 300 ft by 2 ft. Total volume 1,670 CY.
	Benzo(a)pyrene	18		
	Benzo(b)fluoranthene	16		
	Dibenz(a,h)anthracene	5.9 J		
	Indeno(1,2,3-cd)pyrene	13		
030-S-0147-01	Arsenic	4.8	Location unknown.	None.

Notes:
J = Concentration is estimated.
D = Concentration is obtained from a diluted sample.
CY = cubic yards
mg/kg = milligrams per kilogram

The total soil volume impacted at Site 30 is approximately 2,577 CY. Location 030S0102 is adjacent to contamination identified at Site 11. To facilitate remedial activities, remediation in this area will be integrated with Site 11 results. Remediation at Site 30 will focus on activities on the western portion of OU 2. The total volume to be addressed by Site 30, therefore, is approximately 1,837 CY. The areal distribution of contaminated media is shown in Figure 7-5.

7.3 Site 30 Soil Technologies Screening

Table 7-7 presents various remedial technologies applicable to PAHs, PCBs, and arsenic in soil. This table evaluates each technology's applicability to Site 30, and is used to screen out technologies that are infeasible given site conditions. As discussed in Section 2, technologies have been screened for implementability, effectiveness, and cost.

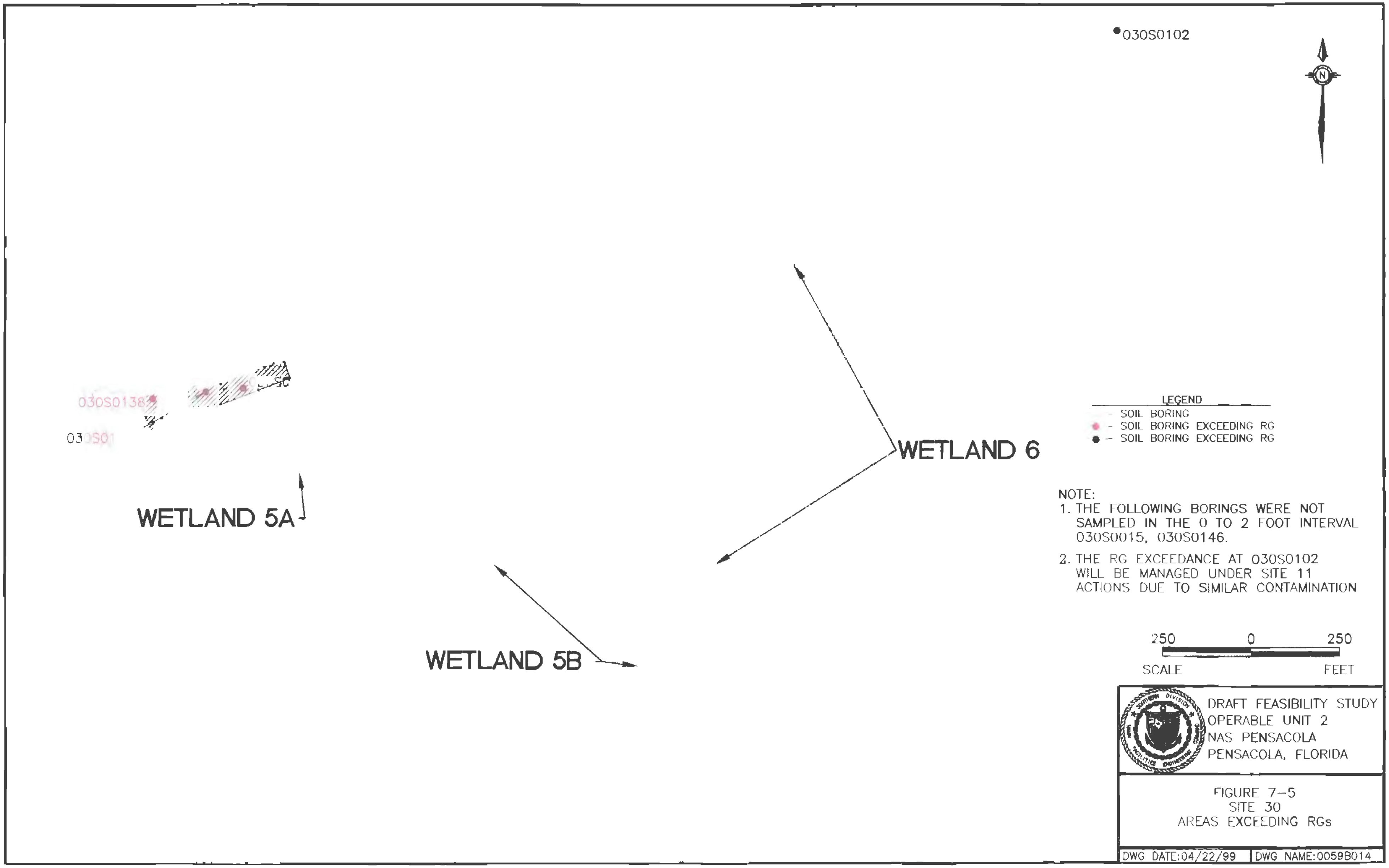

030S0102
030S0138
WETLAND 5A
WETLAND 5B
WETLAND 6
LEGEND
- SOIL BORING
- SOIL BORING EXCEEDING RG
- SOIL BORING EXCEEDING RG
NOTE:
1. THE FOLLOWING BORINGS WERE NOT SAMPLED IN THE 0 TO 2 FOOT INTERVAL 030S0015, 030S0146.
2. THE RG EXCEEDANCE AT 030S0102 WILL BE MANAGED UNDER SITE 11 ACTIONS DUE TO SIMILAR CONTAMINATION
250 0 250
SCALE FEET
DRAFT FEASIBILITY STUDY
OPERABLE UNIT 2
NAS PENSACOLA
PENSACOLA, FLORIDA
FIGURE 7-5
SITE 30
AREAS EXCEEDING RGs
DWG DATE:04/22/99
DWG NAME:0059B014

Table 7-7
Soil Technology Screening - Site 30

Technology	Description	Implementability	Effectiveness	Cost
CONTAINMENT				
Surface Cap	Capping is a containment technology that will limit human contact with soil and reduce infiltration of rainwater through contaminated soil. Capping materials include soil, asphalt, and concrete.	All contamination identified at Site 30 is adjacent to roadways or parking lots. Contaminated areas may be paved easily.	Caps eliminate the ingestion/ inhalation/contact pathway, and therefore are effective at reducing risk to human health. With ongoing maintenance, the long-term effectiveness of a cap is high. Capping is an effective means of eliminating risk pathways, but it does not meet any preference for treatment, nor does it reduce contaminant toxicity, mobility, or volume.	Because this cap is intended only to eliminate a risk pathway and not to isolate waste or reduce infiltration, a multi-layer cap is not required. Costs for common capping material, such as soil, asphalt, or concrete, are comparatively low. Maintenance costs are also low.
IN SITU TREATMENT TECHNOLOGIES				
Bioremediation	Naturally occurring microbes are stimulated by amending contaminated soils to enhance biodegradation. Nutrients, oxygen, hydrogen peroxide, and other amendments may enhance biodegradation and contaminant desorption from subsurface materials. Amendments may be added through solution (such as water), or they may be mixed int the soil using tillers or rippers. When mechanical mixing is required, such as with in situ land farming applications, in situ bioremediation effectiveness is limited at depth. Similarly, effectiveness may be limited if deeper zones exhibit preferential pathways and nutrient/amendment delivery is irregular. Bioremediation may occur in aerobic and anaerobic conditions. In some cases, commercially obtained microbes may be used to supplement native populations.	Bioremediation may be technically implementable at Site 30, contamination is limited to the top 2 feet, and thus may easily be controlled. All areas except 030S0138 are easily isolated from nearby activities. Soil from location 030S0138 represents less than 10% of the contaminated volume; PCB contaminated soil, which may be less amenable to bioremediation, may be managed separately without difficulty.	In situ bioremediation may be less effective at Site 30 due to the varying contaminants which exceed ISCTLs. Of site contaminants, only PAHs and PCBs may be treated using biodegradation Arsenic contamination is not amenable to biological techniques, but only one location (030S0137) contained arsenic above ISCTLs. Because contamination is limited to the top 2 feet, it may be easy to monitor and control. In addition, the porous nature of the impacted media may facilitate uniform amendment delivery. Degradation of PAHs and PCBs is typically slower than more amenable compounds, such as BTEX. Although high concentrations of heavy metals, highly chlorinated organics, long-chain hydrocarbons, or inorganic salts are likely to be toxic to microorganisms, these conditions do not exist at Site 30. Because the remedial goals for several PAH compounds are low, less than 1 mg/kg, it may be difficult to sustain a microbial population at this low concentration. Bioremediation enhances biodegradation, and therefore is considered a destructive technology.	Bioremediation costs are typically variable because the need for amendments is highly site specific. However, in situ bioremediation costs are typically lower than other in situ technologies such as SVE.

Table 7-7
Soil Technology Screening - Site 30

Technology	Description	Implementability	Effectiveness	Cost
Bioventing	Air is either extracted from or injected into the unsaturated soils to increase oxygen concentrations and stimulate biological activity. Bioventing is applicable for any contaminant that more readily degrades aerobically than anaerobically. This process is used to deliver amendments to zones deeper than what can be managed by bioremediation practices alone. Flow rates are much lower than soil vapor extraction, minimizing volatilization and release of contaminants to the atmosphere. Where preferential pathways exist in the vadose zone, air flow may not reach all contaminated media.	Bioventing is not technically implementable to Site 30, given that contamination is limited to the 0- to 2-foot interval. Administrative implementability is also limited given current and future site use.	Bioventing is unlikely to be more effective than natural degradation processes at this site, given that surface soil is already highly oxygenated. Bioventing enhances biodegradation, and therefore is considered a destructive technology.	Bioventing is relatively inexpensive, though ongoing use of blowers and ancillary piping will require O&M.
Phytoremediation	Phytoremediation is the use of plants to remove, contain, and/or degrade contaminants Examples include plant-enhanced bioremediation, phytoaccumulation, phytodegradation, and phytostabilization. Climatic or hydrologic conditions may restrict the rate of growth of the remediation plants	Phytoremediation may be technically implementable at Site 30; contamination is limited to the top 2 feet, and thus there is likely a wide variety of plants which may be used to remediate site soil. Implementation of phytoremediation will require identifying a plant or plants amenable to all site compounds (PAHs, PCBs, arsenic), and optimizing growing conditions. Because remediation time frames may be long, plans for future site use may be impacted by phytoremediation. Due to time required for remediation, plans for future site use may be impacted by phytoremediation.	Phytoremediation is an innovative technology that may be effective at Site 30 given that contamination is limited to the top 2 feet bgs, well within the root zones of some plants. Shallow contamination is easily monitored and controlled. Although high concentrations of hazardous materials can be toxic to plants, contaminant concentrations at Site 30 are not excessive Phytoremediation may be a destructive remediation technology, depending on the type of plants used. It may also be used as a containment or immobilization strategy, binding contaminants in soil or biomass However, there is concern that phytoremediation is reversible. Additionally, plants that have died or which are removed from the site may require special management or handling due to concentrated contaminants within the biomass.	Costs for phytoremediation are expected to be low compared with other in situ techniques. Maintenance costs are also expected to be relatively low, consisting of monitoring and watering costs.

Table 7-7
Soil Technology Screening – Site 30

Technology	Description	Implementability	Effectiveness	Cost
In Situ Solidification/ Stabilization	In situ stabilization immobilizes contaminants by mixing site soil with portland cement, lime, or a chemical reagent to reduce the mobility of the contaminant. Large augering equipment is used to mix soils in place with the reagent. This technology will likely leave a solid mass (similar to concrete) onsite.	This technology is technically implementable at Site 30. Contaminated soil is limited to the 0- to 2-foot interval, which is easily mixed. The stabilized mass may be left in place.	Solidification/stabilization can be an effective containment strategy for organic compounds. However, this technology works better for inorganics including radionuclides. Some organic-contaminated soils may delay or inhibit reactions necessary for solidification. Long-term, the stabilized mass can degrade, particularly if subject to repeated abuse. Solidification/stabilization is not a permanent treatment technology and does not remove or destroy contaminants; rather, contaminants are immobilized. Treated media typically must be managed long term (e.g., through institutional controls and monitoring).	Solidification/stabilization costs typically vary given the stabilizing material required (e.g., fly ash, portland cement, etc.). However, these costs are typically low compared with destructive in situ options.
EX SITU TREATMENT TECHNOLOGIES				
Solid-phase biodegradation • Biopiles • White rot fungus • Landfarming	Excavated soils are mixed with amendments, nutrients, enzymes, or fillers and placed in aboveground enclosures. Mixing may be required, as in a traditional landfarming application. Conversely, biopiles may be used simply to deliver oxygen uniformly throughout a large pile. Ex situ biological systems may be designed to degrade specific compounds and maintain specified degradation conditions (aerobic vs. anaerobic). Mechanical mixing, such as tilling or turning of windrows, may be required	Ex situ bioremediation is technically implementable at Site 30. Each contaminant may require different biological conditions for optimum degradation; therefore, three different approaches may be required (one for PAHs, one for PCBs, and one for arsenic). A large amount of space is required for solid phase ex situ bioremediation	Ex situ bioremediation systems may be tailored to the specific contaminant requiring treatment. Biodegradation is typically limited to organic compounds, and heavy metals may be toxic to microorganisms. Remediation half-lives for PAHs and PCBs may be slower than more degradable compounds, such as BTEX, which may extend the remediation time frame. Arsenic concentrations are will not be reduced through biological activity. It may be necessary to isolate contaminated soil with similar contaminant concentrations and thus optimize treatment specifically for PAHs and PCBs. Remedial goals for some PAHs; are less than 1 mg/kg, and may be inadequate to sustain a microbial population without a supplemental carbon source Solid phase bioremediation is a permanent, destructive technology.	Ex situ solid phase bioredmeation is inexpensive compared with other ex situ techniques. However, given the need to design specific nutrient amendments and process control systems, more recalcitrant organics are typically more expensive to treat.

Table 7-7
Soil Technology Screening – Site 30

Technology	Description	Implementability	Effectiveness	Cost
Slurry Phase Biological Treatment	Slurry-phase bioreactors containing co-metabolites and specially adapted microorganisms can be used to treat halogenated VOCs and SVOCs, pesticides, and PCBs. An aqueous slurry is created by combining soil with water and other additives. The slurry is mixed continuously to keep solids suspended and microorganisms in contact with the soil contaminants. Upon completion of the process, the slurry is dewatered and the treated soil is disposed of.	Ex situ bioremediation is technically implementable at Site 30. Each contaminant may require different biological conditions for optimum degradation; therefore, three different approaches may be required (one for PAHs, one for PCBs, and one for arsenic). A large amount of space is required for slurry phase ex situ bioremediation.	Slurry-phase bioreactors are used primarily to treat nonhalogenated SVOCs and VOCs in excavated soils or dredged sediments. Ex situ bioremediation systems may be tailored to the specific contaminant requiring treatment. Biodegradation is typically limited to organic compounds, and heavy metals may be toxic to microorganisms. Arsenic contamination at Site 30 will not be treated by biological remedies. Remediation half-lives for PAHs and PCBs may be slower than more degradable compounds, such as BTEX, which may extend the remediation time frame. If supplemental carbon is required to sustain microbes and improve treatment system effectiveness, application rates can be easily controlled in a slurry system. Slurry phase bioremediation is a permanent, destructive technology.	Ex situ slurry phase bioremediation is expensive compared with other biological techniques, due to the controls and materials handling required.
Soil Washing • Chemical Extraction • Acid Extraction • Solvent Extraction • Separation Techniques	Excavated soil is washed with aqueous-based solutions to separate contaminants sorbed onto fine particles from the rest of the soil matrix The fractions of soil to be treated are processed in a slurry with specific leachant mixtures to ionize target metals. The solvent/waste mixture is then treated further to develop a concentrated leaching solution. which may be treated or disposed offsite. Traditional soil washing options may also include separation techniques which concentrate contaminated solids through physical and chemical means These processes seek to detach contaminants from their medium (e g , soil, sand, or other binding material). Gravity separation, magnetic separation, and sieving/physical separation are examples of this technology.	With approximately 2,500 CY of contaminated soil, soil washing may be implementable at Site 30 The system must be designed to remove each contaminant identified at Site 30: PAHs, PCBs, and arsenic This may mean three different solvents and/or processes are used. Volumes may be sufficient to justify the treatability analysis and process optimization required for implementation. Soil washing systems will require operational space as well as possible water and sewer connections.	Overall, this technology is effective at removing SVOCs and inorganics. It is less effective at treating VOCs. In general, acid extraction techniques are suitable for treating soils contaminated by heavy metals. Solvent extraction has been shown to be effective in treating soils containing primarily organic contaminants, but is generally least effective on very high molecular-weight organic and very hydrophilic substances. Effectiveness may be better controlled by segregating soil (by contaminant type) and treating each contaminant exclusively Soils with higher clay content may reduce extraction efficiency and require longer contact times. High humic content in soil may require pretreatment. It may be difficult to remove organics adsorbed to clay-size particles. Soil washing is a permanent treatment technology which removes contaminants from soil to another medium (e.g., solvent, carbon, etc) Treatment residuals then may require treatment or disposal Soil washing solvents may also pose environmental risks.	Soil washing is typically an expensive remediation alternative because of the highly site-specific design requirements and the need to treat and/or dispose of the leaching solvent. With approximately 2,500 CY of contaminated soil, soil washing may be possible at Site 30 assuming treatability studies are favorable and can be cost effectively focused on specific site contaminants.

Table 7-7
Soil Technology Screening – Site 30

Technology	Description	Implementability	Effectiveness	Cost
Chemical/ Physical Oxidation • permanganate flooding • Fenton's reagent • Wet air oxidation • Supercritical water oxidation	Chemical oxidation is a process in which the oxidation state of a contaminant is increased while the oxidation state of the reactant is decreased. The reactant can be another element, including the oxygen molecule, or it may be a chemical species containing oxygen, such as hydrogen peroxide or chlorine dioxide. In the case of physical oxidation technologies, wet air oxidation and supercritical water oxidation both use high pressure and temperature to treat organic contaminants.	With approximately 2,500 CY of contaminated soil, chemical/physical oxidation may be implementable at Site 30. Treatability studies must be performed to determine reagent doses. Iron and manganese in the soil will compete with contaminants for oxygen.	This technology is effective in treating media contaminated with halogenated and non-halogenated volatiles and semivolatiles, PCBs, pesticides, cyanides, and volatile and nonvolatile metals. Wet air oxidation can treat hydrocarbons and other organic compounds. Supercritical water oxidation is applicable for PCBs and other stable compounds. Oxidation is a permanent treatment technology, in which contaminants are destroyed.	Costs for chemical oxidation processes may be comparable to soil washing costs, given the need to construct and operate ex situ reactors, and the need to control reagents and reactor conditions. Costs may vary widely with the type of oxidation technique implemented.
Ex Situ Solidification/ Stabilization	Contaminants are physically bound or encased within a stabilized mass, or chemical reactions are induced with stabilizing agents. The contaminants are not removed or destroyed, but their mobility is reduced Examples of S/S technologies include bituminization, emulsified asphalt, modified sulfur cement, polyethylene extrusion, pozzolan/portland cement, radioactive waste solidification, sludge stabilization, and soluble phosphates	Ex situ stabilization/ solidification is the best-demonstrated technology for multiple compounds. It is technically implementable, and often required to render contaminants non-hazardous before offsite disposal Site contaminants are non-hazardous PAHs,, PCBs, and arsenic, and it is unlikely that it will be necessary to render these concentrations lower to meet treatment standards.	This technology works well for inorganics including radionuclides. Although organic-contaminated soil may be treated with solidification/stabilization, some organics can delay or inhibit reactions necessary for solidification. Solidification/ stabilization is not a permanent treatment technology and does not remove or destroy contaminants; rather, contaminants are immobilized. Treated media typically must be managed appropriately, i.e., landfilled or contained onsite. Where used as asphalt or similar covers, degradation due to normal asphalt weathering should be considered.	Solidification/stabilization costs typically vary given the stabilizing material required (e.g., fly ash, portland cement, etc.). However, ex situ stabilization/ solidification is inexpensive, compared with other ex situ technologies

Table 7-7
Soil Technology Screening - Site 30

Technology	Description	Implementability	Effectiveness	Cost
Incineration/ Pyrolysis	Incineration burns contaminated sediment at high temperatures (1,600° - 2,200°F) to volatilize and combust organic contaminants. A combustion gas treatment system must be included with the incinerator. The circulating bed combustor, fluidized bed reactor, infrared combustor, and rotary kiln are several types of incinerators Pyrolysis is a thermal process that chemically changes contaminated sediment by heating it in the absence of air. Pyrolysis can be achieved by limiting oxygen to rotary kilns and fluidized bed reactors. Molten salt destruction is another example of pyrolysis	Incineration is technically implementable at Site 30. However, the lead agency will likely be reluctant to construct an incineration unit for a small-volume, short-term project. Administrative implementability will be limited by the need for submitting documentation and testing the unit's compliance with ARARs. Administrative implementability is also limited given current and future site use. Highly abrasive feed can damage the processor unit. The technology requires drying the soil to achieve less than 1% moisture content.	Incineration may be effective in treating organic-contaminated soil, but not for soil with metals as the primary contaminants. The target contaminant groups for pyrolysis are SVOCs and pesticides. Pyrolysis is not effective in either destroying or physically separating inorganics from the contaminated medium. Volatile metals may be removed by the higher temperatures, but are not destroyed. Incineration is a permanent treatment technology; COCs are destroyed during treatment.	Incineration/ pyrolysis are typically very expensive remedial options compared with other ex situ remediation. The low contaminant concentrations at Site 30 can be treated using other technologies, rendering this technology cost-prohibitive.
Thermal Desorption	Soil is generally heated between 200 and 1,000 F to separate VOCs, water, and some SVOCs from the solids into a gas stream The organics in the gas stream must be treated or captured. Thermal desorption may be used at high or low temperatures depending on the volatility of the contaminants	Thermal desorption is technically implementable at Site 30. Some thermal desorbers may be regulated as incinerators, depending on construction. Testing and optimization would be required. Highly abrasive feed can damage the processor unit. Although clay and silty soils and soil with high humic content increase reaction time due to binding of contaminants, this problem would not be anticipated for Site 30.	Thermal desorption units are effective at removing primarily organic contaminants. Residence time and temperature inside the unit can be varied to volatilize recalcitrant organics. Inorganic contaminants or metals that are not particularly volatile will not be effectively removed by thermal desorption. Arsenic contaminated soil will not be addressed by this technology. Vapor phase organics must be concentrated and treated or otherwise disposed of. Thermal desorption is a permanent treatment technology which will eliminate risk by removing COCs from site soil.	Although less expensive than other ex situ thermal treatment methods, thermal desorption is still comparatively expensive. Costs increase with the degree of materials handling, pre-and post- treatment, and off-gas controls required. With approximately 2,500 CY of contaminated soil, thermal desorption may be possible at Site 30 assuming treatability studies are favorable and can manage specific site contaminants cost effectively.

Table 7-7
Soil Technology Screening - Site 30

Technology	Description	Implementability	Effectiveness	Cost
Excavation and Offsite Disposal	Contaminated soil is excavated and disposed of offsite at a licensed waste disposal facility.	Excavation with offsite disposal is both technically and administratively implementable at Site 30. Contaminated media can be removed and disposed offsite. The excavated areas can then be backfilled with clean fill with minimal impact to operations at adjacent buildings. Testing will be required before the soil is disposed of; TCLP results may impact disposal options. Transporting the soil through populated areas may affect community acceptance. Any excavations within the flood plan must comply with floodplain requirements.	Excavation with offsite disposal is expected to be an effective remediation option. It is effective for all contaminants because the risk pathway is eliminated. This is a permanent remedial technology.	Costs for excavation and offsite disposal vary depending on whether waste is classified as hazardous. However, compared with other options (including treatment or disposal at an incineration facility), landfilling is relatively less expensive.

The technologies retained for use at Site 30 after screening are:

- No Action, as required by the NCP.
- Institutional controls, which will be needed to maintain the industrial-use classification
- Capping
- In situ bioremediation
- Phytoremediation
- Excavation with offsite disposal

Table 7-7 includes screening comments for each technology;, the rationale for discarding other potential technologies is discussed in the following paragraphs

Iin situ and ex situ solidification/stabilization was discarded primarily because these technologies are used to minimize leaching and contaminant mobility, particularly for inorganics. PAHs, PCBs and inorganics encountered at this site are not present at high concentrations and do not pose a threat to the underlying aquifer These technologies were discarded in favor of more applicable responses.

Ex situ reactor-based treatment, such as solid and slurry phase biodegradation, soil washing, and chemical oxidation, are all high-cost technologies which require significant capital for system construction. Effectiveness of each of these technologies is highly variable, and depends on site specifics such as soil parameters, and chemicals constituents. Effectiveness is also questionable as contaminant concentrations approach RGs; remediation of PAHs may not be sustainable at concentrations of 1 part per million or less These technologies were discarded in favor of in situ approaches with similar uncertainties.

Thermal treatments, such as incineration, pyrolysis, and thermal desorption, although effective for organic compounds, were discarded because of the high costs and implementation obstacles associated with meeting ARARs. If thermal treatment is identified at another site as a viable option, consolidation might be considered. However, contamination across OU 2 is significantly low enough that other treatment options will likely meet the statutory preference for treatment.

7.4 Site 30 Assembly of Alternatives

The following alternatives have been retained for Site 30 soil.

- Alternative 1. No Action
- Alternative 2. Institutional controls
- Alternative 3: Asphalt Cap
- Alternative 4: Plant-enhanced bioremediation with offsite disposal of PCB contaminated soil
- Alternative 5 Excavation with Offsite Disposal

7.4.1 Alternative 1: No Action

Under this alternative, no changes would be made to site existing operations or exposure scenarios. While the current and projected land use for this site is expected to remain industrial, there are no institutional controls to guarantee the exposure pathway would remain industrial. Without controls, a residential scenario must be assumed in which all existing pavement and buildings are removed

Implementability

The no-action alternative could be easily implemented. The Navy would be required to perform a 5-year review to assess adequacy of the alternative.

Effectiveness

The no-action alternative is not effective at protecting human health, as site contaminants above residential and industrial SCTLs are left onsite. As discussed in the BRA, Site 30 soil presents a combined soil ingestion/contact pathway risk of 2.7E-05 to potential future site residents; this risk is within the allowable range cited in the NCP (1E-06 to 1E-04), but exceeds the FDEP threshold criteria of 1E-06.

Cost

Table 7-8 presents the costs associated with the no-action alternative.

Table 7-8
Alternative 1 — Costs for No Action

Action	Quantity	Cost per Unit	Total Cost
Five Year Review	LS[a]	$10,000	$10,000
Present value sub total at 6% discount over 30 years			$24,400
Total Cost			**$24,400**

Notes:
LS = Lump sum
Cost based on review once every five years for 30 years.

7.4.2 Alternative 2: Institutional Controls

No remedial actions will be implemented under this alternative. Institutional controls such as LUCAs would be implemented to limit access and property use to industrial/commercial, thereby limiting unacceptable exposure to contamination.

This alternative does not require any changes to existing activities, since current land use at Site 30 is industrial. However, controls would be required to minimize exposures which could include maintenance activities in impacted areas. Notification of the Base Environmental office would be required to ensure proper instruction before invasive activities begin.

Implementability

Implementation of this alternative does not require any innovative technologies or construction activities; ongoing operations would not be interrupted. This alternative would require the Navy to control site access and keep its use industrial/commercial. Site access can be controlled through the LUCA and/or warnings against excavation. The site would be inspected annually to ensure compliance with the LUCA. If the property was no longer under direct Navy control, development of a deed restriction would be necessary. The Navy has base planners and attorneys on staff with experience to develop and implement proper institutional controls for Site 30 The possibility of transferring Site 30 to civilian control is highly unlikely in the near future; therefore, proper controls can be implemented through planning

The NCP requires any alternative which leaves contamination onsite to be reevaluated every 5 years to ensure its adequacy. Therefore, the institutional controls alternative would require the Navy to establish a monitoring program.

Effectiveness

Institutional controls at Site 30 would limit unacceptable exposure to surface soil contamination. Under current site conditions, surface soil exceeds the ISCTLs at four sample locations where surface soil is exposed. This alternative would not provide any additional effectiveness for the current use scenario, but would provide long-term effectiveness by restricting future use and access. However, workers would be exposed only during activities in which they contact surface soil. No risks are posed during implementation of institutional controls.

This alternative also ensures intrusive activities are not permitted in or near other impacted areas where concentrations exceeded ISCTLs.

This alternative does not provide more protection to site workers than the current scenario, but it does eliminate the future resident exposure pathway by excluding the property from residential use. Likely exposures will be less than the worst case assumed in SCTL development (see *Technical Report: Development of Soil Cleanup Target Levels*, ERC Hearing Draft, May 1999).

As demonstrated in the BRA, Site 30 exhibits a combined ingestion/contact pathway risk of 5.1E-06 for future site workers. This risk is on the low end of the NCP's allowable risk range of 1E-06 to 1E-04 for the industrial scenario but exceeds the FDEP threshold of 1E-06.

Cost

The total-present worth cost of the institutional controls alternative is estimated at $74,400.

As shown in Table 7-9, the Navy assumes implementation of institutional controls will cost approximately $50,000 which is the estimated cost for completing the necessary documentation and annual review of site use In addition a 5-year reevaluation of site conditions will be required for 30 years, as per the NCP. The estimated cost for each reevaluation is $10,000 per event; assuming a 6% discount rate over 30 years, the present worth of reevaluation requirements is approximately $24,400.

Table 7-9
Alternative 2 - Institutional Controls

Action	Quantity	Cost per Unit	Total Cost
Five Year Review	LS	$10,000	$10,000
Present value sub total at 6% discount over 30 years			$24,400
Institutional Controls (LUCA and Signs)	LS	$50,000	$50,000
Total Cost			$74,400

Notes:
LS = Lump sum
Cost based on review once every five years for 30 years.

7.4.3 Alternative 3: Asphalt Cap

Installing an asphalt cover would reduce the risk of site workers contacting exposed contaminated soil, thus eliminating exposure pathways. Institutional controls would also be incorporated to restrict future access to contaminated soil.

Remedial activities for the asphalt cover would consist of:

- Implementing institutional controls (LUCA)
- Confirmatory sampling
- Site preparation
- Cover placement

Cover construction would consist of a 4- to 8- inch asphalt pavement placed over contaminated soil areas The pavement would be sloped to direct runoff toward open or grassy areas where percolation may occur Confirmation sampling would help delineate the extent of soil in which contaminant concentrations exceed the RG to ensure that all contaminated soil is covered.

Implementability

Cover construction with institutional controls is technically feasible at Site 30. Land use restrictions may be used to implement institutional controls. The Site 30 area that would be covered are shown in Figure 7-6, Proposed Cover Locations. The total area to be covered is presented in Table 7-10 below. Actual areas to be covered will be determined in the field following confirmation sampling. The site is suitable for asphalt or concrete covering to protect site workers from contaminated soil; asphalt was selected over alternative capping materials so that the paved areas may be used for parking or access.

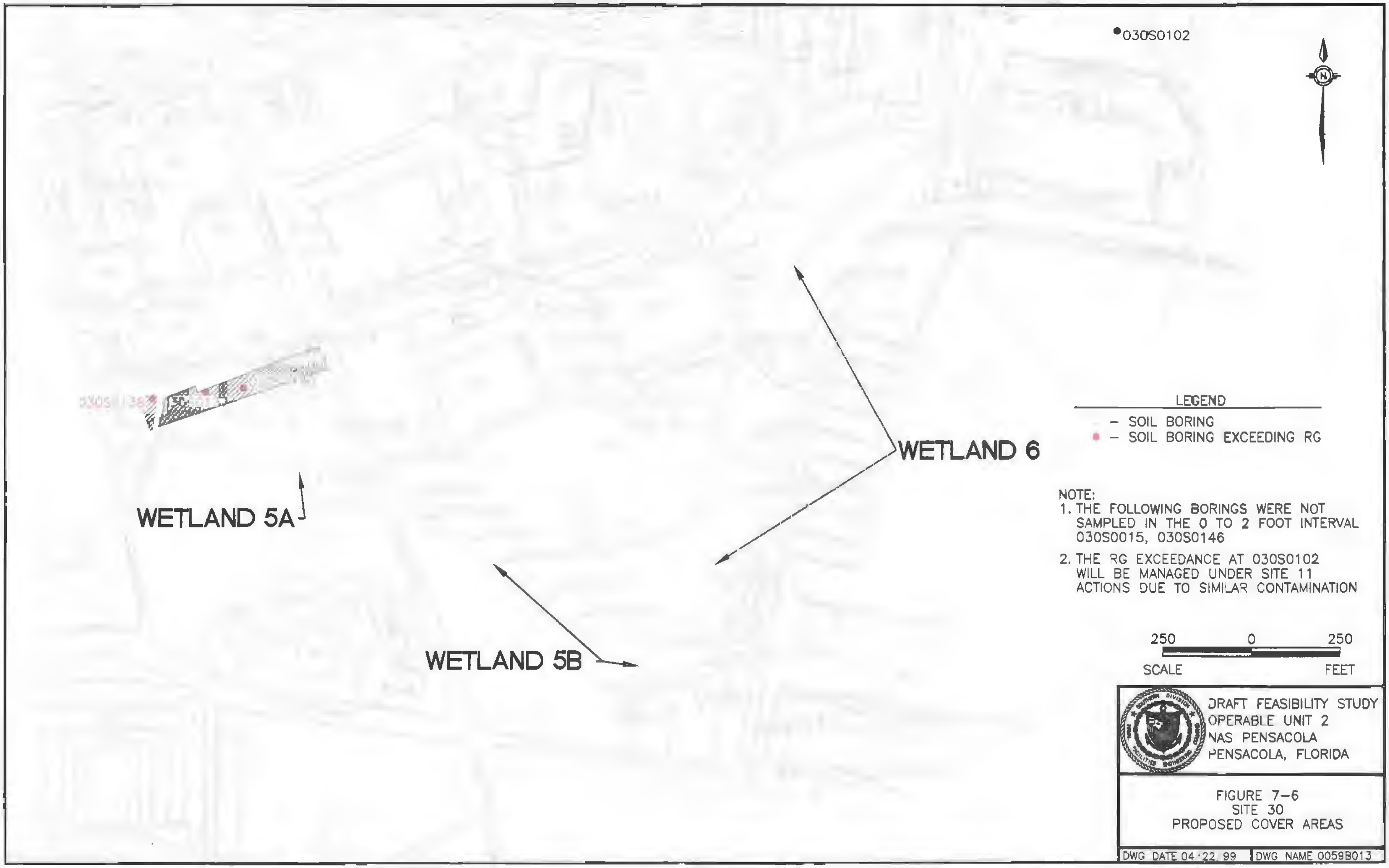


FIGURE 7–6
SITE 30
PROPOSED COVER AREAS

Table 7-10
Areas to be Paved

Location	Estimated Pavement Dimensions	Surface Area (ft^2)
030S0138	triangular 90 ft by 50 ft	2,250
030S0137 and 030S0140	500 ft by 65 ft	32,500
Total Paved Area		34,750

Effectiveness

Covers provide reliable protection against dermal contact with and ingestion of contaminated soil. They isolate contaminants exceeding risk and guidance concentrations in environmental media, but are not designed to manage solid or hazardous waste. Confirmation sampling will enusre that the entire area exceeding RGs is covered. Once the cover is in place, institutional controls would help ensure continued cover effectiveness and regular maintenance would be required.

Cost

Table 7-11 presents the capital costs associated with installation of an asphalt cover and institutional controls.

Table 7-11
Alternative 3 — Costs for Asphalt Cover

Action	Quantity	Cost per Unit	Total Cost
Capital Costs for Asphalt Cover			
Mobilization/Demobilization	LS	$500/location	$1,000
Grading/site preparation	3,861 yd^2	$1.50/$yd^2$	$5,790
Asphalt/Concrete Surface (8" depth)	34,750 ft^2	$1.76/$ft^2$	$61,160
Engineering/Oversight	LS	20% cost	$13,590
Contingency/Miscellaneous	LS	25% cost	$16,990
Subtotal			$98,530

Table 7-11
Alternative 3 — Costs for Asphalt Cover

Action	Quantity	Cost per Unit	Total Cost
Operation and Maintenance Cost			
Maintain cover (30 years)	3,861 yd^2	\$2/yd^2	\$7,720
Inspection	LS	\$500	\$500
Subtotal			**\$8,220**
Present value at 6% discount over 30 years			\$113,150
Confirmation Sampling	12 samples (plus 2 QA/QC samples)	\$750/sample	\$10,500[a]
Institutional Controls (LURA and signs)		LS	\$50,000
Subtotal			**\$60,500**
Remedial Contractor Cost			\$100,000
Total Cost			**\$372,180**

Notes:
LS = Lump sum
[a] Assumes one sample will be collected along each edge of the contaminated area. Samples will be analyzed for SVOCs, pesticides/PCBs, and inorganics.
ft^2 = square foot
yd^2 = square yard

7.4.4 Alternative 4: Plant-Assisted Bioremediation with Offsite Disposal of PCB-Contaminated Soil

Plant-assisted bioremediation would be implemented at at Site 30 which exhibit primarily PAH contamination.

Impacted areas would be remediated using existing microbial populations and supplementing them with nutrients. Moisture and other soil properties would be optimized to enhance biological activity. If bench- and pilot-scale work indicated that bioremediation alone was insufficient to achieve RGs, plant-enhanced bioremediation (otherwise known as phyto-stimulation) would be implemented to augment microbial degradation. Plant-assisted bioremediation uses plants to stimulate microbial activity within the root zone: plants provide supplemental carbon and oxygen within the contaminated zone, thus improving degradation kinetics. Phytoremediation mechanisms can remove contaminants directly through mineralization (also called transformation) of contaminants to carbon dioxide and water, or through uptake, in which contaminants are concentrated in vegetation or root-mass. Other species can stabilize contaminants, generally metals, through changes in oxidation/reduction conditions and precipitation, thus reducing toxicity and/or mobility.

Remedial activities would include:

- Implementing institutional controls (LUCA)

- Bench-scale laboratory testing to determine soil properties (optimal moisture content, pH, etc.), amendment requirements (oxygen, nitrogen, phosphorus) and degradation rates

- Research to determine optimal plants for PAH remediation in northwest Florida.

- Field-scale testing to evaluate in situ degradation rates with and without supplemental plants.

- Construction of treatment areas, including

    — Berms and access controls
    — Irrigation systems
    — Nutrient metering tanks and pumps

- Ongoing monitoring and tillage (if required)

- Excavation of PCB-contaminated soil at 030S0138 and offsite disposal at a Subtitle D landfill, with subsequent backfill of the 030S0138 area.

Implementability

Bioremediation of PAH-contaminated soil technically implementable at Site 30. Pilot-scale testing would be necessary prior to full-scale treatment. Institutional controls would be required to restrict access to impacted areas during remediation, and to control future use. The shallow contamination and porous soil are amenable to in situ biological technologies. If pilot scale studies indicate that nutrient amendments alone are insufficient to reduce contaminant concentrations to RGs, bioremediation may be supplemented with phytoremediation. Phytoremediation is an innovative technology noted to be effective at PAH sites (Pradhan, 1998). Additional research and pilot testing will be required to identify plants appropriate to PAH degradation in northwest Florida. It is important to note that detection limits seen in current analytical techniques (such as CLP SVOCs or SW-846 Method 8270) are only slightly lower than site specific RGs; analytical interferences, which are common for soil analyses, may elevate detection limits above site RGs, making it difficult to assess remediation progress when soil concentrations drop below 1 mg/kg.

Effectiveness

Bioremediation alternatives are expected to be effective in reducing contaminant concentrations; effectiveness may be limited, however, as concentrations approach RGs. It is possible that organic contaminant concentrations in the low part-per-million range are insufficient to support microbial populations. It may be possible to enhance degradation through phytoremediation; although it is unclear if phytoremediation techniques can achieve significant reductions when bioavailability is low (i.e., biomass may be the limiting factor). Plant-assisted bioremediation, in addition to supplementing microbial activity, can remove contaminants directly from soil — either through uptake into vegetation, or thorough transformation (mineralization) within the root system.

Remediation timeframes for both bioremediation and phytoremediation depend on site-specific degradation kinetics.

Cost

Bioremediation costs typically range from \$50 to \$150 per cubic yard, excluding bench and pilot scale testing. Phytoremediation is a new technology, and costs for full-scale projects are not available. However, it is considered a low-cost adjunct to engineered biodegradation, with literature estimates of total remediation costs (including grading, planting, monitoring, etc.) between \$60,000 and \$100,000 per acre (less than \$2.50/ft^2). Because of the uncertainties associated with an innovative technology, \$2.50/ft^2 has been used to estimate costs, but actual costs may be lower. If transfer to vegetation is the primary removal mechanism, and plants will require harvesting and disposal, costs will likely increase. Table 7-12 presents theoretical costs for a bioremediation system at Site 30, assuming unit costs and basic construction.

Table 7-12
Alternative 4 — Costs for Plant Assisted Bioremediation

Action	Quantity	Cost per Unit	Total Cost
Capital Costs for Plant-Assisted Bioremediation			
Mobilization/Demobilization	LS	\$500/location	\$1,500
Grading/site preparation	3,611 yd^2	\$1.50/yd^2	\$5,420
Bioremediation	2,407 CY	\$50 to \$150/CY	\$120,350 to \$361,050
Phytoremediation	32,500 ft^2	\$2.50/ft^2	\$81,250
Engineering/Oversight	LS	20% cost	\$89,840
Contingency/Miscellaneous	LS	25% cost	\$112,310
Subtotal			**\$651,370**
Operation and Maintenance Cost			
Maintenance (30 years)	LS	5,000	\$5,000
Monitoring	4 samples/year (plus 2 QA/QC)	\$500/sample	\$3,000
Inspection	LS	\$500	\$500
Subtotal			**\$8,500**
Present value at 6% discount over 30 years			**\$117,000**

Table 7-12
Alternative 4 — Costs for Plant Assisted Bioremediation

Action	Quantity	Cost per Unit	Total Cost
Excavation of PCB-contaminated Soil at 030S0138			
Excavation	167 CY	$20/CY	$3,340
Confirmation Sampling	4 samples (plus 2 QA/QC samples)	$300/each	$1,800 [a]
Backfill	217 CY	$15/CY	$3,255 [c]
Transportation	11 trucks (assuming 20 CY each) hauling 30 miles	$3.50/loaded mile	$1,155 [d]
Soil Disposal	250 tons	$36/ton	$9,020 [5]
Engineering/Oversight	LS	20% cost	$2,040
Contingency/Miscellaneous	LS	25% cost	$2,540
Subtotal			$23,150
Institutional Controls (LURA and signs)		LS	$50,000
Remedial Contractor Cost			$100,000
Total Cost			$941,520

Notes:
LS = Lump sum
[a] = Assumes four samples will be collected within contaminated area. Samples will be analyzed for SVOCs and inorganics.
[b] = Assumes 4 samples will be collected inside the excavation area. Samples will be analyzed for pesticides/PCBs.
[c] = Assumes 30% fluff following removal.
[d] = Assumes 1.5 tons per cubic yard.

7.4.5 Alternative 5: Excavation with Offsite Disposal

This alternative involves excavating surface soil in which contaminants exceed compound-specific RGs and disposing of it offsite. Approximately 1,840 yd^3 of surface soil, as depicted in Figure 7-5, would be removed to eliminate threats to current or future industrial site workers through dermal and ingestion exposure pathways. Since soil removal is based on meeting ISCTLs, institutional controls (the LUCA) will be used to ensure that future use remains industrial.

Because contaminant concentrations are relatively low (1 to 10 part-per-million range), Site 30 soil is not expected to be considered hazardous waste. Remedial activities would consist of

- Implement institutional controls (LUCA)
- Excavation
- Confirmatory sampling
- Backfill
- Transporting excavated material offsite
- Landfill at a Subtitle D facility

Confirmation sample would be collected from surface soil surrounding the excavation would be conducted to ensure complete removal of surface soil in which contaminant concentrations exceed RGs

After the contaminated soil is removed clean backfill would be placed in the excavated areas and graded. TCLP analysis would be conducted to determine if the excavated soil exhibits toxicity characteristics.

Implementability

This alternative is both technically and administratively feasible at Site 30. Excavation is performed frequently and is a reliable method to remove contaminated soil within given boundaries. No technology-specific regulations apply to excavation and offsite disposal (i.e., landfilling) alternatives. Except for implementing land use restrictions, no long-term maintenance or monitoring would be required once soil in which contaminant concentrations exceed RGs has been removed. Based on groundwater elevation data presented in the RI report, groundwater is not expected to pose a problem during excavation.

Administrative considerations would include:

- Transportation and disposal of contaminated soil must adhere to USDOT regulations and requirements.

- Scheduling would be required to reduce costs for roll-off boxes and downtime while transporting the soil from Site 30 to the disposal facility.

- Daily operations at the surrounding activities will likely be interrupted on a short-term basis by access problems during the removal process

No capacity limitations are expected at the landfill, given low projected soil volumes.

Effectiveness

Excavation with offsite disposal would protect the environment at Site 30 by reducing the amount of soil in which contaminant concentrations exceed RGs onsite.

Short-term inhalation, ingestion, and contact risks to site workers (excavation crew) would temporarily increase during excavation (last only until remedial actions are complete. Onsite actions will require health and safety practices consistent with PAH contamination and dust generation. These risks will be reduced through proper use of PPE and engineering controls. Because no residential areas are adjacent to Site 30, there are no short-term risks to the surrounding community. No onsite long-term risks are associated with this alternative because exposed soil in which contaminants exceed the ISCTL industrial threshold would be removed.

Cost

Table 7-13 presents the capital costs associated with excavation and offsite disposal at a Subtitle D facility.

Table 7-13
Alternative 5 – Costs for Excavation with Offsite Disposal

Action	Quantity	Cost per Unit	Total Cost
Excavation	1,840 yd^3	$20/$yd^3$	36800
Confirmation Sampling	15 samples (plus 3 QA/QC samples)	$750/sample	$13,500 [a]
Backfill	2,392 yd^3	$15/$yd^3$	$35880 [b]
Subtotal			$86,180
Subtitle D Disposal Facility			
Transportation	120 trucks (assuming 20 yd^3 each) hauling 30 miles	$3.50/loaded mile	$12,600 [c]
Soil Disposal	2,760 tons	$36/ton	$99,360 [d]
Engineering/Oversight	LS	20% cost	$22,390
Contingency/Miscellaneous	LS	25% cost	$27,990
Subtotal			$162,340
Institutional Controls (LUCA and signs)			$50,000
Remedial Contractor Cost			$100,000
Total			$398,520

Notes:
[a] = Four samples will be collected around each contaminated boring. Samples will be analyzed for SVOCs, pesticides/PCBs, and inorganics.
[b] = Assumes 30% fluff after excavation.
= Assumes 1.5 tons per cubic yard.
yd^2 = square yard

7.5 Site 30 Detailed Analysis of Alternatives

The following alternatives have been retained for Site 30 soil:

Alternative 1: No Action

Alternative 2: Institutional Controls

Alternative 3: Asphalt Cover

Alternative 4: Plant-Enhanced Bioremediation/PCB-Contaminated Soil Removal

Alternative 5: Excavation and Offsite Disposal

Each alternative is evaluated according to the nine criteria discussed in Section 2, which have been divided into the three categories — threshold, balancing, and modifying.

7.5.1 Alternative 1: No Action

The no-action alternative for Site 30 involves no active remedial effort. No actions will be taken to contain, remove, or treat soil contamination above RGs. Soil will remain in place No engineering or institutional controls will be implemented The no-action alternative provides a baseline against which other alternatives can be compared

No Action Threshold Criteria

Overall Protection of Human Health and the Environment· The no-action alternative provides no additional protection of human health and the environment. This alternative assumes that future use will be residential. Site 30 soil exceeds RSCTLs at 12 locations. These exceedances would remain onsite, unmitigated. Under an uncontrolled use scenario, the BRA calculated site risks to be 2.7E-5 (hypothetical residential exposure).

Compliance with ARARs: Alternative 1 does not comply with the RGs developed for Site 30; moreover, contaminants will pose risk under an uncontrolled future use scenario. Florida Proposed Rule 62-777 is a potential ARAR for OU 2. No location- or action-specific ARARs are triggered by the no-action alternative

No Action: Balancing Criteria

The primary balancing criteria are the technical criteria on which the detailed analysis is based.

Long-term Effectiveness and Permanence: Long-term effectiveness of the no-action alternative is minimal. Soil volumes and concentrations would remain unchanged. In addition, the no-action alternative does not reduce the magnitude of residual risk and lacks treatment actions that would provide permanence.

Any controls currently in place at the site — military security and limited access to/use of the site — would remain. If use were unrestricted, no controls would be in place to protect potential receptor groups (i.e., residents).

Reduction of Toxicity, Mobility, or Volume Through Treatment: This alternative would not reduce soil contaminant mobility, toxicity or volume Contaminants would remain untreated and in place

Short-Term Effectiveness: Short-term effectiveness assesses an alternative's effect on human health and the environment while it is being implemented There are no such effects from the No-action alternative

Implementability: The No-action alternative is technically feasible and easily implemented. No construction, operation, or reliability issues are associated with this alternative. Current access controls — including military security and limited personnel access to the site — have historically been reliable. No administrative coordination, offsite services, materials, specialists, or innovative technologies are required. There are no implementation risks associated with Alternative 1.

Cost: Costs include a site review and report preparation every five years for 30 years. Each review and report are estimated to cost $10,000, with a present-worth of $24,400 for the 30-year period.

No Action: Modifying Criteria

The modifying criteria are assessed formally after the public-comment period. However, the criteria are factored into identifying the preferred alternatives, as far as they are known.

State/Support Agency Acceptance: FDEP and the USEPA will have the opportunity to review and comment on this FS.

Community Acceptance: These criteria are generally not completed until after public comments on the RI/FS report and the proposed plan are received.

7.5.2 Alternative 2: Institutional Controls

The institutional controls alternative for Site 30 involves no active remedial effort. No actions will be taken to contain, remove, or treat soil contamination above RGs Soil would remain in place and institutional controls would be incorporated into the LUCA to ensure Site 30 remains an industrial use area

Institutional Controls: Threshold Criteria

Overall Protection of Human Health and the Environment: The institutional controls alternative provides additional protection of human health and the environment by reducing the potential for uncontrolled site access. By restricting use to industrial/commercial, risks from residential ingestion of or contact with soil are eliminated. However, soil contamination at Site 30 exceeds industrial RGs and poses a threat under a future worker scenario. The BRA calculated a risk of 5.1E-06 for site workers under an industrial-use scenario.

Compliance with ARARs: Alternative 2 does not comply with the RGs established for Site 30; Florida Proposed Rule 62-777 is a potential ARAR. No location- or action-specific ARARs are triggered by the institutional controls alternative. Contaminated soil would remain above the RGs.

Institutional Controls: Balancing Criteria

The primary balancing criteria are the technical criteria on which the detailed analysis is based.

Long-Term Effectiveness and Permanence: The long-term effectiveness of institutional controls is limited to the ability to control access to contaminated soil. Soil volumes and concentrations would remain unchanged, and there are no treatment actions that would provide permanence.

Reduction of Toxicity, Mobility, or Volume Through Treatment: The institutional controls alternative would not reduce the mobility, toxicity, or volume of soil contaminants. Contaminants would remain untreated and in place onsite.

Short-Term Effectiveness. Short-term effectiveness assesses an alternative's effect on human health and the environment while it is being implemented There are no short-term effects resulting from the institutional controls alternatives.

Implementability: The institutional controls alternative is technically feasible and easily implemented. No construction issues are associated with this alternative. Current access controls — including military security and limited personnel access to the site — have historically been reliable and will be supplemented through land use restrictions. Administrative coordination is required to implement institutional controls, but no offsite services, materials, specialists, or innovative technologies would be required. There are no implementation risks with Alternative 2.

Cost: Costs include soil monitoring and report preparation every five years for 30 years plus the cost of establishing the institutional controls. Each sampling and reporting event is estimated to cost $10,000, with a present worth of $24,400 for the 30-year period. Providing the necessary institutional controls is estimated to be a one-time cost of $50,000, for a total cost of $74,400.

Institutional Controls: Modifying Criteria

The modifying criteria are assessed formally after the public-comment period. However, the criteria are factored into identifying the preferred alternatives, as far as they are known.

State/Support Agency Acceptance: FDEP and the USEPA will have the opportunity to review and comment on this FS.

Community Acceptance: These criteria are generally not completed until after public comments on the RI/FS report and the proposed plan are received.

7.5.3 Alternative 3: Asphalt Cover

This alternative uses a physical barrier to cover the three locations where contaminants exceed RGs (note, location 030S0102 is included in the Site 11 remedy) In conjunction with the cover alternative, land use will be restricted to industrial to minimize uncontrolled exposure and prevent cover disturbance..

Asphalt Cover: Threshold Criteria

Overall Protection of Human Health and the Environment: The asphalt cover would eliminate the threat of dermal and ingestive contact for current and future site workers. Contaminated soil would be left onsite indefinitely and the cover maintained to ensure adequate protection.

This alternative would protect human health and the environment by physically eliminating receptor pathways and controlling access through land use restrictions. Cover construction and maintenance would be easily implemented and current site controls (site security, access control, and fencing) and the LUCA would be adequate to ensure minimal disturbance of onsite covers. Short-term risks during implementation from inhalation and dermal contact would be minimal, and could be controlled using common engineering techniques and use of PPE.

Compliance with ARARs: The asphalt cover with the associated institutional controls would comply with RGs for future industrial workers to protect human health. The potential for contact with soil in which contaminants exceed ISCTLs is eliminated by removing the primary pathways.

The cover would isolate or eliminate contaminants exceeding RGs in environmental media, but not manage solid or hazardous waste. Site grading would need to comply with federal, state, and local air emissions and storm water control regulations. Remedial actions at Site 30 may trigger the following ARARs:

- Flood plain requirements as outlined in the *National Environmental Policy Act* (40 CFR Part 6, Appendix A), *Fish and Wildlife Coordination Act* (40 CFR 6 302)

- Storm water discharge requirements as outlined in the *Clean Water Act* (40 CFR 122, 125, 129, 136) and the *Florida Storm Water Discharge Regulations* (FAC 62-25).

Asphalt Cover: Balancing Criteria

Long-Term Effectiveness and Permanence: An asphalt cover would effectively reduce site worker dermal or ingestive contact with contaminated soil and would require inspection and maintenance. Asphalt covers are generally reliable containment controls but if the asphalt degraded or was removed, repairs could be made to re-establish the cover's integrity.

This alternative eliminates residual risk to site workers by managing Site 30 as an industrial site and restricting land use. The use of these covered areas would be controlled institutionally.

Reduction of Toxicity, Mobility, or Volume Through Treatment: Constructing an asphalt cover at Site 30 would not remove, treat, or remediate the contaminated soil; it provides containment only. The cover is considered reversible, because contaminants exceeding RGs under the cover would remain onsite; if the cover fails because of poor maintenance, contaminants may be exposed. This alternative would not reduce toxicity, mobility, or volume through treatment, nor would it satisfy the statutory preference for treatment.

Short-Term Effectiveness: Adverse impacts to the surrounding environment are not anticipated during cover construction; engineering controls would be applied to manage storm water runoff and siltation. Once design plans are approved, actual cover construction would be expected to take less than one month. During construction, workers would be at risk for dermal or ingestive contact with soil contaminants; however, this risk would be reduced by proper removal practices and use of PPE

Implementability: An asphalt cover with institutional controls and limited excavation is technically and administratively feasible This alternative could be readily applied at the site, because the proposed areas to be covered are easily accessible. Current access controls have been reliable and will be supplemented through the LUCA, and thus, implementing this alternative would merely involve placement of the cover and implementation of the LUCA. Future monitoring and maintenance would involve preiodic visual cover inspections and repairing any damage or degradation. Repairs are easily implemented, and asphalt covering would not require any extraordinary services or materials.

Cost: Costs for this alternative are detailed in Section 7.4.3. The total cost for Alternative 3 including the cover, institutional controls, excavation, and the corrective action contractor is $372,180 (net present value) O&M costs comprise approximately 30% of the net present value.

Soil Cover: Modifying Criteria

State/Support Agency Acceptance: FDEP and the USEPA will have the opportunity to review and comment on this FS.

Community Acceptance: These criteria are generally not completed until after public comments on the RI/FS report and the proposed plan are received.

7.5.4 Alternative 4: Plant-Enhanced Bioremediation/PCB-Contaminated Soil Removal

A combination of bioremediation and phytoremediation techniques is used in this alternative to treat contaminated soil in situ PCB-contaminated soil are removed from the area around 030S0138 and transported offsite for disposal. Land use is restricted to industrial, as Site 30 RGs are only protective of site workers.

Plant-Enhanced Bioremediation: Threshold Criteria

Overall Protection of Human Health and the Environment: Plant-enhanced bioremediation is protective of human health as treatment reduces COC concentrations. Bioremediation provides high levels of effectiveness and permanence: residual risks are eliminated once treatment is completed, since degradation is permanent and no untreated wastes are left onsite. As with all biological degradation processes, incomplete degradation is possible, resulting in generation of more toxic byproducts. Bench- and pilot-scale testing will indicate if this is a concern at Site 30. Removal of PCB-contaminated soil near 030S0138 is protective of human health and the environment; soil will be secured in a secure, permitted landfill.

Compliance with ARARs: This alternative would comply with RGs for future industrial workers. Possible location- and action-specific ARARs include:

- Floodplain requirements as outlined in the *National Environmental Policy Act* (40 CFR Part 6, Appendix A), *Fish and Wildlife Coordination Act* (40 CFR 6.302).

- Storm water discharge requirements as outlined in the *Clean Water Act* (40 CFR 122, 125, 129, 136) and the *Florida Storm Water Discharge Regulations* (FAC 62-25).

- USDOT transportation requirements.

- Solid waste disposal requirements (soil is not expected to exhibit hazardous waste characteristics).

Plant-Enhanced Bioremediation: Balancing Criteria

Long-term Effectiveness and Permanence: The bioremediation alternative permanently minimizes risks associated with the contaminated soil by treating approximately 2,407 CY of contaminated soil in place It is possible that bioremediation will not be able to achieve RGs, as these goals approach the lower limit for sustaining microbial populations. However, contaminant degradation reduces overall risk, and supplementation of traditional bioremediation techniques with phytoremediation promise to enhance removal rates. Arsenic contamination is not typically amenable to biological activity, but plant uptake may reduce soil concentrations. Institutional controls would be required to restrict access during the remediation period, as well as to limit future site use to industrial. The PCB removal at 030S0138 is effective and permanent, removing contaminated soil from the site; approximately 167 CY will be removed.

Reduction of Toxicity, Mobility, or Volume through Treatment: The bioremediation alternative reduces the toxicity, mobility, and volume by actively biodegrading site contaminants. This satisfies the statutory preference for using treatment as a principal element. Treatment is irreversible, although stabilization through precipitation or reduction may be reversed if oxidation/reduction conditions in the root zone change. If phytoremediation plants require harvesting to enhance removal rates, the harvested biomass may require special disposal as a treatment residual, depending on contaminant concentrations. Excavation and offsite disposal of PCB-contaminated soil does not meet the statutory preference for treatment, though it does reduce contaminant concentrations present onsite.

Short-term Effectiveness: The plant-enhanced bioremediation alternative poses minimal dermal or inhalation risks to workers: exposures will occur primarily during grading and planting activities. Any risks posed during implementation of either the bioremediation system or during the PCB-contaminated soil removal can be controlled with dust control technologies and a site-specific health and safety plan that specifies PPE, respiratory protection, etc. Remedial time frames for bioremediation are not quantifiable without pilot-scale studies. System design, soil and contamination heterogeneities, fate processes of the various constituents, etc., will impact degradation kinetics.

Implementability: Plant-enhanced bioremediation is technically and administratively feasible at Site 30. Phytoremediation is an innovative technology, with significant ongoing research Bench-and pilot-scale testing will be required to determine degradation rates, amendment requirements, and optimal plant species given site characteristics. Monitoring this remedy is possible through standard analytical protocols: phytoremediation techniques may draw on standard agricultural rather than environmental analyses. Degradation rates may be limited if contaminant concentrations are too low to support microbial activity. Analytical detection limits may restrict determination of low concentrations due to common matrix interferences. Because PAH contaminant RGs are low (some less than 1 part per million), RGs actually may be lower than analytical detection limits. Degradation may be hard to quantify at low levels, particularly if kinetics are slowed by poor bioavailability. Removal of soil from 030S0138 is implementable; no obstacles are anticipated.

Cost: The net present worth of plant-assisted bioremediation and PCB excavation ranges from $700,820 to $941,520, including institutional controls and annual monitoring. Because combined bioremediation/phytoremediation technologies are innovative, this number is an estimate. Bench-and pilot-scale testing will be required to refine site-specific costs.

Plant-Enhanced Bioremediation: Modifying Criteria

State/Support Agency Acceptance: FDEP and the USEPA will have the opportunity to review and comment on this FS.

Community Acceptance: These criteria are generally not completed until after public comments on the RI/FS report and the proposed plan are received.

7.5.5 Alternative 5: Excavation and Offsite Disposal

The primary element of this alternative is the excavation of soil contaminated above RGs from the site and disposal in an approved landfill. Land use is restricted to industrial to minimize uncontrolled exposure.

Excavation and Offsite Disposal: Threshold Criteria

Overall Protection of Human Health and the Environment: Excavation and offsite disposal protects human health and the environment by removing contaminated soil posing a risk above RGs. Risk to human health and the environment from contaminants exceeding ISCTLs would be eliminated. Short-term risks during implementation from inhalation and dermal contact would be minimal, and could be controlled with common engineering techniques and use of PPE. The alternative could be easily implemented and would protect current and future site workers and the environment.

Compliance with ARARs: Excavation would meet chemical-specific ARARs for the associated RGs which protect future industrial site workers. Possible location- and action-specific ARARs include:

- Flood plain requirements as outlined in the *National Environmental Policy Act* (40 CFR Part 6, Appendix A), *Fish and Wildlife Coordination Act* (40 CFR 6.302).

- Storm water discharge requirements as outlined in the *Clean Water Act* (40 CFR 122, 125, 129, 136) and the *Florida Storm Water Discharge Regulations* (FAC 62-25).

- USDOT transportation requirements

- Solid waste disposal requirements (soil is not expected to exhibit hazardous waste characteristics)

Limited Excavation to Industrial Scenario and Offsite Disposal: Balancing Criteria

Long-Term Effectiveness and Permanence: The excavation alternative would remove the contaminated soil from the site and dispose of it in a permitted Subtitle D facility. This alternative would eliminate risk from contaminants exceeding RGs. Soil remaining onsite would not threaten human health under an industrial-use scenario. The LUCA will effectively control future land use..

Excavation with disposal in an offsite landfill is a particularly reliable option because soil removal from the site would eliminate risks. Some future liability might be incurred through disposal at a landfill.

Reduction of Toxicity, Mobility, or Volume Through Treatment: The excavation with disposal at an offsite landfill alternative would not satisfy the preference for treatment. Although it is anticipated that excavated soil is non-hazardous, TCLP analysis will be performed for verification.

Excavation would eliminate the source area and therefore, the contaminants exceeding RGs. This alternative includes the removal of approximately 1,840 CY of surface soil from the site which would be isolated in a secure landfill. Because the source would no longer remain onsite, excavation is considered permanent. Mobility, toxicity and volume would not be reduced and the preference for treatment would not be satisfied.

Short-Term Effectiveness: Excavation would be sufficiently removed from the public to reduce health and safety concerns associated with soil removal. Excavation workers would be exposed to increased particulate emissions and might also have more dermal contact with hazardous constituents However, worker risks can be reduced with dust control technologies and a site-specific health and safety plan that specifies PPE, respiratory protection, etc

Implementability: Excavation with offsite landfilling is technically and administratively feasible at Site 30. Removal and offsite disposal have been commonly applied at previous sites. The only potential technical problems that might slow down removal activities are materials handling and disposal (standby time between confirmatory sampling and disposal). Landfill debris, if present within the 0- to 2-foot interval, may require disposal at a debris landfill. Areas to be excavated are readily accessible. and no future remedial actions would be required after this alternative is completed.

This alternative would not require any extraordinary services or materials.

Cost: Detailed costs associated with Alternative 5 are presented in Section 7.4.5. Total direct costs for excavation and disposal at a Subtitle D facility are estimated to be $398,520. No O&M costs are associated with this alternative.

Excavation and Offsite Disposal: Modifying Criteria

State/Support Agency Acceptance: FDEP and the USEPA will have the opportunity to review and comment on this FS.

Community Acceptance: These criteria are generally not completed until after public comments on the RI/FS report and the proposed plan are received

7.6 Site 30 Comparative Analysis of Alternatives

The Site 30 comparative analysis of alternatives is presented in Table 7-14

Table 7-14
Comparative Analysis of Site 30 Soil Alternatives

Evaluation Criteria	Alternative 1: No action	Alternative 2: Institutional Controls	Alternative 3: Asphalt Cover	Alternative 4: Plant-Enhanced Bioremediation	Alternative 5: Excavation and Offsite Disposal
Threshold Criteria					
Protection of human health and the environment (HH&E)	No action is implemented. Because the site's future use is uncontrolled and site contaminants exceed residential standards, there is potential risk to future site residents.	Institutional controls are implemented to restrict land use and therefore minimize uncontrolled exposures. Because locations exceed industrial standards, there is potential risk to current and future site workers.	Soil cover will eliminate the dermal contact and ingestion pathway; the LUCA will limit site use to industrial, thus minimizing uncontrolled exposures.	Bioremediation and phytoremediation degrade and/or immobilize site contaminants to eliminate risks to HH&E. Treatment reduces COC concentrations.	Offsite disposal is a highly effective and reliable way to eliminate risk above RGs. Removal of contaminated media from the site is protective of current and future site workers.
Compliance with ARARs	Current conditions do not meet RGs. While risk is within USEPA's acceptable risk range onsite risks exceed FDEP's threshold criteria of 1E-06	Current conditions do not meet RGs While risk is within USEPA's acceptable risk range, onsite risks exceed FDEP's threshold criteria of 1E-06	Soil cover will eliminate surface soil pathways, and therefore meet RGs Actions would require compliance with storm water and floodplain requirements.	Treatment techniques are effective with PAHs, degradation may achieve RGs Actions would require compliance with storm water and floodplain requirements.	Removal would comply with RGs, and all actions would require compliance with storm water and floodplain requirements.
Balancing Factors					
Long-term effectiveness and permanence	None.	Institutional controls are effective at limiting access The LUCA will need to be maintained.	Covers are effective at eliminating the risk pathway. Maintenance will be required to ensure effectiveness.	Bio- and phytoremediation permanently reduce risks through degradation of site COCs. Although it is possible that as contaminants approach RGs concentrations may not sustain microbial populations, the overall reduction in contaminant concentrations achieved will reduce site risk. Institutional controls will limit future site use.	Excavation and offsite disposal eliminates risk onsite. The LUCA will restrict land use to industrial and eliminate unrestricted exposures.
Reduction of Toxicity, Mobility, or Volume through Treatment	None	None	None	Toxicity is reduce through degradation, phytoremediation can also immobilize contaminants Degradation is irreversible, precipitates may be solubilized if oxidation/ reduction conditions change	None
Short-Term Effectiveness	No risks are associated with the no-action alternative.	No risks are associated with institutional controls.	Implementing the remedy will require less than 1 month; short-term exposures may be reduced by engineering controls and PPE.	Remediation time frames are long, likely greater than 5 years. Short-term exposures may be reduced by engineering controls and PPE.	Implementing the remedy will require less than 1 month; short-term exposures may be reduced by engineering controls and PPE.

Table 7-14
Comparative Analysis of Site 30 Soil Alternatives

Evaluation Criteria	Alternative 1: No action	Alternative 2: Institutional Controls	Alternative 3: Asphalt Cover	Alternative 4: Plant-Enhanced Bioremediation	Alternative 5: Excavation and Offsite Disposal
Implementability	Technically and administratively feasible Easily implemented	Technically and administratively feasible Easily implemented	Technically and administratively feasible Easily implemented.	Phytoremediation is innovative, with significant ongoing research, and pilot work will be required, additional work will be required to scale up the remediation system, Implementability may be constrained by analytical detection limits	Technically and administratively feasible Easily implemented
Cost	**Capital:** none **Annual:** $10,000, every 5 years **PW:** $24,000	**Capital:** $50,000 **Annual:** $10,000, every 5 years **PW:** $74,000	**Capital:** $259,030 **Annual:** $8,220 **PW:** $372,180	**Capital:** $475,500 to $824,520 **Annual:** $8,500 **PW:** $592,500 to $941,520	**Capital:** $398,520 **Annual:** $0 **PW:** $398,520
Modifying Criteria					
State/Support Agency Acceptance	FDEP and USEPA will have opportunity to review and comment on this technology	FDEP and USEPA will have opportunity to review and comment on this technology	FDEP and USEPA will have opportunity to review and comment on this technology	FDEP and USEPA will have opportunity to review and comment on this technology	FDEP and USEPA will have opportunity to review and comment on this technology
Community Acceptance	Community acceptance will be established after the public comment period.	Community acceptance will be established after the public comment period.	Community acceptance will be established after the public comment period.	Community acceptance will be established after the public comment period.	Community acceptance will be established after the public comment period.

8.0 SITES 11, 12, AND 26 GROUNDWATER FEASIBILITY EVALUATION

Groundwater concentrations have been compared to ARARs — FPDWS, FSDWS, FSWQs, MSWQs, and PQGs. All exceedances reported in the RI were reviewed to determine whether they indicated a contaminant plume or mass that poses a risk to human health or the environment. Groundwater was assessed to delineate areas requiring feasibility study.

To discuss ARAR exceedances, groundwater has been discussed site-by-site. Sites 11, 12, and 26 and Sites 25, 27, and 30 have been grouped together to better understand where exceedances occur and to facilitate remedial planning for groundwater at OU 2. Sites 11, 12, and 26 are discussed as a group in Section 8; exceedances at Sites 25, 27, and 30 are discussed in Section 9.

Naturally occurring inorganic compounds in the shallow aquifer have been detected in background samples at concentrations indicating a poor water quality aquifer, not a *usable* drinking water source As such, primary (sodium) and secondary inorganic compounds (aluminum, calcium, copper iron magnesium manganese, and vanadium) that exceeded FPDWS and FSDWS criteria were excluded from groundwater exceedance evaluations since their concentrations are typical of natural conditions While these compounds may affect remedial technology selection and design, they are not considered significant environmental concerns.

Moreover, in general, total metals concentrations (primary and secondary metals) were significantly lower during Phase II sampling and reasonably commensurate to background concentrations when low-flow sampling techniques were used in place of traditional bailing. Therefore, it was concluded that elevated metals concentrations detected relatively site wide during Phase I were induced by sampling rather than actual aquifer conditions.

Inorganic compounds that exceeded secondary criteria are listed in Appendix B.

8.1 Nature of Contamination

8.1.1 Site 11 ARAR Exceedances

Comparison with FPDWS and FSDWS Criteria

Phase I

In samples from every shallow and intermediate well location, contaminants exceeded at least one FPDWS and FSDWS criteria. Excluding secondary metals, samples from 9 of 15 shallow well locations had exceedances of at least one FPDWS criteria. The criteria were exceeded by primary metals (barium, cadmium, and lead), VOCs (1,1,2,2-tetrachloroethane, 1,2-DCE [total], TCE, and vinyl chloride), SVOCs (2-methylnapthalene and napthalene), and pesticides/PCBs (aldrin and dieldrin). Metals exceedances are distributed randomly throughout the site reducing the possibility of a single contaminant source VOC exceedances (primarily chlorinated organics) are in the northern (wells 11GS28 and 11GS47) and southern (well 11GS52) portions of the site. Wells 11GS03 and 1GM36 were contaminated with dieldrin which is consistent with Phase I pesticides contamination at Sites 12 and 26

Excluding secondary metals, samples from 5 of 9 intermediate well locations had exceedances of at least one FPDWS criteria. The contaminants that exceeded FPDWS criteria were primary metals (arsenic, beryllium, chromium, lead, and nickel) at well 11G115, VOCs (1,2-DCA, 1,2-DCE (total) , TCE, and vinyl chloride) concentrated along the freshwater creek in the southern portion of the site, and pesticides/PCBs (aldrin) at well 11GI04.

All of the water samples collected from temporary exploratory trenches had exceedances for at least one FPDWS and FSDWS criteria. However, trench water samples may represent sediment-borne contamination rather than groundwater contamination since the samples had high levels of turbidity. Contaminants that exceeded their criteria were primarily metals, further evidence that entrained sediment in the water samples may have caused the them.

Site 11 wells from which samples had exceedances of FPDWS criteria during Phase I sampling are shown on Figure 8-1.

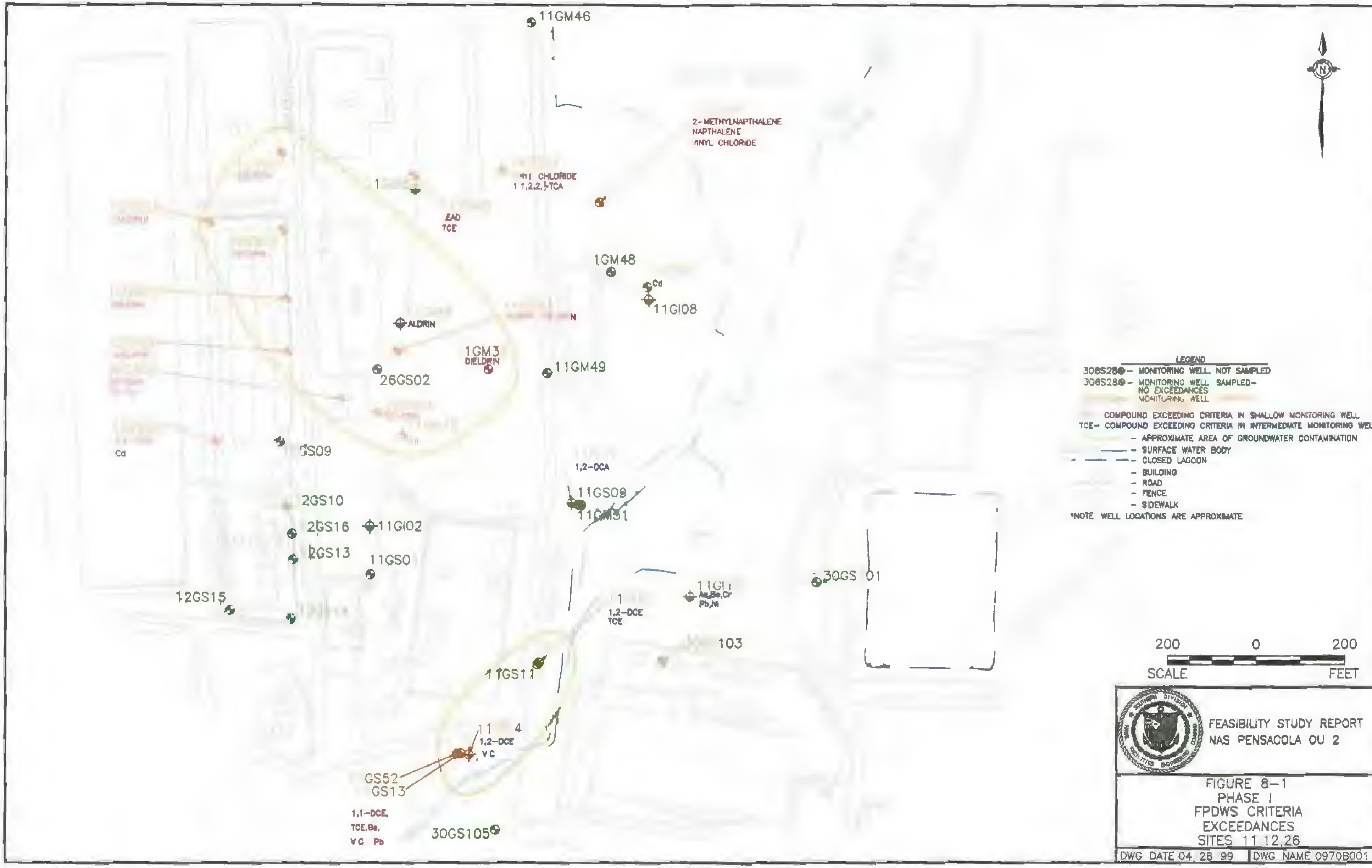
Phase II

Samples from seven out of eight shallow well locations had an exceedance of at least one FPDWS and FSDWS criteria. Excluding secondary metals, samples from five of eight shallow well locations exceeded at least one FPDWS criteria. Contaminants that exceeded their criteria were primary metals (cadmium and lead), VOCs (1,1-DCA, 1,1-DCE, 1,2-DCE, benzene, tetrachloroethene, TCE, and vinyl chloride), and SVOCs (2-Methylnapthalene and napthalene). Metals are distributed randomly throughout the site, diminishing the possibility of a single source VOCs tend to be concentrated in the northern portion of the site and along the freshwater creek SVOC exceedances were only detected in well 11GS47

Excluding secondary metals, samples from two of four intermediate well locations (11GI12 and 11GI14) had exceedances of at least one FPDWS criteria Contaminants were 1,2 DCE, TCE, and vinyl chloride. Site 11 wells in which samples exceeded FPDWS criteria during Phase II are shown on Figure 8-2.

Based on Phase I and II sampling, VOC contamination is concentrated around well 11GS47 and along the freshwater creek in wells 11GI12, 11GS13, 11GI14, and 11GS52 in the southern portion of the site. Because upgradient wells in these areas do not seem to be contaminated with VOCs, these wells may be exhibiting isolated residual contamination from past localized activities in the northern and southern portions of the site.

Table 8-1 lists the compounds exceeding the FPDWS criteria and the locations where the exceedances occurred.


11GM46
2-METHYLNAPTHALENE
NAPTHALENE
VINYL CHLORIDE
1 1,2,2,-TCA
TCE
1GM48
Cd
11GI08
ALDRIN
1GM3
DIELDRIN
11GM49
26GS02
Cd
1,2-DCA
11GS09
2GS10
2GS16
11GI02
2GS13
11GS0
30GS 01
12GS15
As,Be,Cr
Pb,Ni
1,2-DCE
TCE
103
11GS11
1,2-DCE
VC
GS52
GS13
1,1-DCE,
TCE,Be,
VC Pb
30GS105
LEGEND
30GS28 - MONITORING WELL NOT SAMPLED
30GS28 - MONITORING WELL SAMPLED- NO EXCEEDANCES
MONITORING WELL
COMPOUND EXCEEDING CRITERIA IN SHALLOW MONITORING WELL
TCE- COMPOUND EXCEEDING CRITERIA IN INTERMEDIATE MONITORING WELL
- APPROXIMATE AREA OF GROUNDWATER CONTAMINATION
- SURFACE WATER BODY
- CLOSED LAGOON
- BUILDING
- ROAD
- FENCE
- SIDEWALK
*NOTE WELL LOCATIONS ARE APPROXIMATE
200 0 200
SCALE FEET
FEASIBILITY STUDY REPORT
NAS PENSACOLA OU 2
FIGURE 8-1
PHASE I
FPDWS CRITERIA
EXCEEDANCES
SITES 11 12,26
DWG DATE 04 26 99
DWG NAME 0970B001

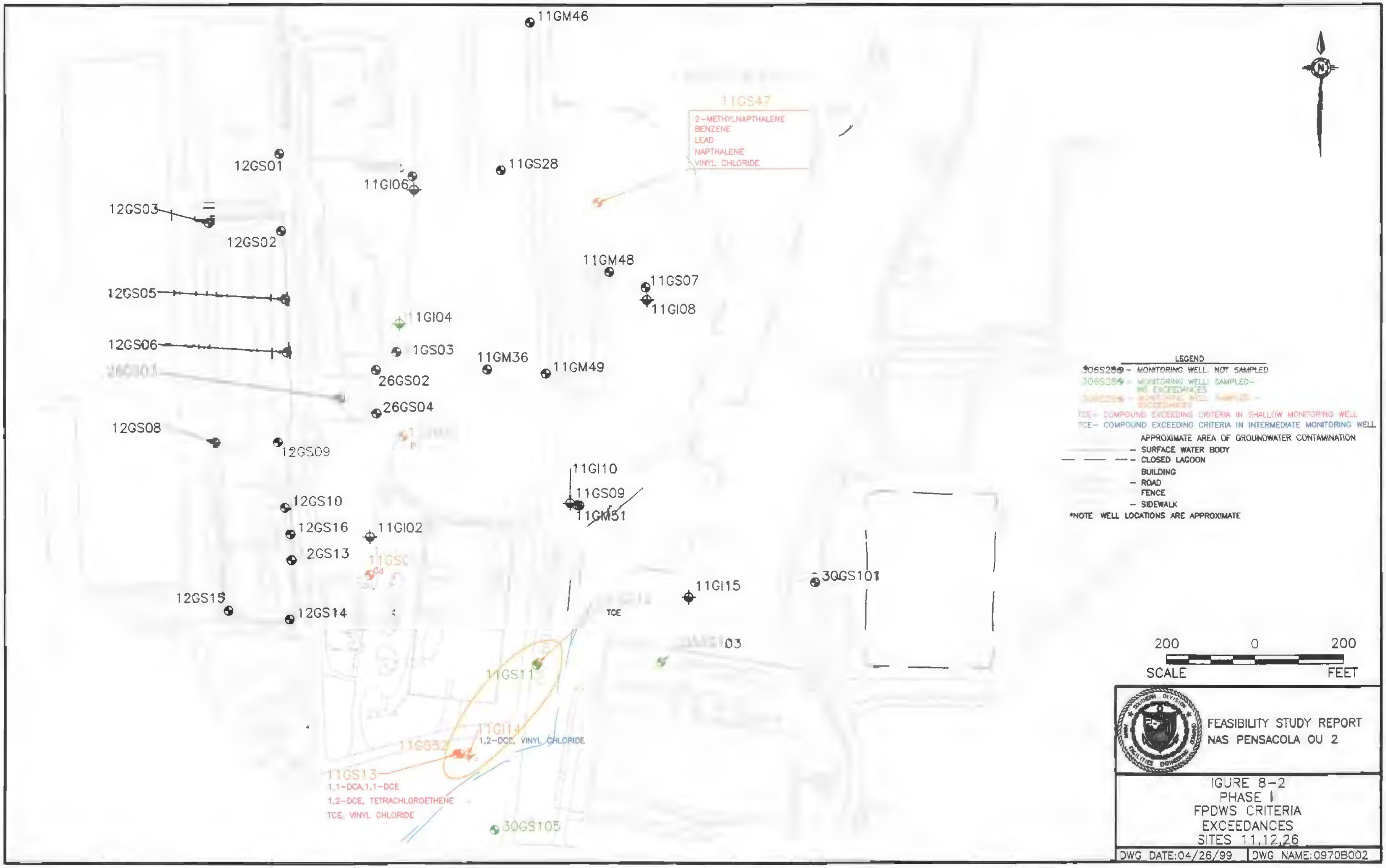

11GM46
11GS47
2-METHYLNAPTHALENE
BENZENE
LEAD
NAPTHALENE
VINYL CHLORIDE
12GS01
11GS28
11GI06
12GS03
12GS02
11GM48
11GS07
11GI08
12GS05
11GI04
12GS06
1GS03
11GM36
11GM49
26GS02
26GS04
12GS08
12GS09
11GI10
11GS09
11GM51
12GS10
12GS16
11GI02
2GS13
12GS15
12GS14
11GI15
30GS101
TCE
11GS11
11GI14
1,2-DCE, VINYL CHLORIDE
11GS52
11GS13
1,1-DCA,1,1-DCE
1,2-DCE, TETRACHLOROETHENE
TCE, VINYL CHLORIDE
30GS105
LEGEND
306S280 – MONITORING WELL NOT SAMPLED
306S280 – MONITORING WELL SAMPLED – NO EXCEEDANCES
TCE – COMPOUND EXCEEDING CRITERIA IN SHALLOW MONITORING WELL
TCE – COMPOUND EXCEEDING CRITERIA IN INTERMEDIATE MONITORING WELL
APPROXIMATE AREA OF GROUNDWATER CONTAMINATION
– SURFACE WATER BODY
– CLOSED LAGOON
BUILDING
– ROAD
FENCE
– SIDEWALK
*NOTE WELL LOCATIONS ARE APPROXIMATE
200 0 200
SCALE FEET
FEASIBILITY STUDY REPORT
NAS PENSACOLA OU 2
IGURE 8-2
PHASE I
FPDWS CRITERIA
EXCEEDANCES
SITES 11,12,26
DWG DATE:04/26/99
DWG NAME:0970B002

Table 8-1
Site 11 FPDWS Criteria Exceedances, Phases I and II

Sample ID	Parameter	Result (µg/L)	
11GS1502	Cadmium	13.9	
11GS1503	Lead	3500.0	
11GS2801	1,1,2,2-tetrachloroethane	2.0	J
	Vinyl chloride	2.0	J
11GS3601	Dieldrin	0.030	J
11GS4701	2-methylnaphthalene	25.0	
	Naphthalene	47.0	
	Vinyl chloride	55.0	
11GS4702	2-methylnaphthalene	40.0	
	Benzene	3.0	
	Lead	1710.0	
	Naphthalene	60.0	
	Vinyl chloride	48.0	D
11GS5201	1,2-dichloroethene (total)	420.0	
	Trichloroethene	20.0	J
	Vinyl chloride	230.0	
11GS5202	1,1-dichloroethane	72.0	D
	1,1-dichloroethene	10.0	
	cis-1,2-dichloroethene	970.0	D
	Tetrachloroethene	23.0	
	Trichloroethene	50.0	
	Vinyl chloride	74.0	D
11GI0401	Aldrin	0.0	J
11GI1001	1,2-dichloroethane	9.0	J
11GI1201	1,2-dichloroethene (total)	110.0	
	Trichloroethene	14.0	
11GI1202	Trichloroethene	11.0	J
11GI1401	1,2-dichloroethene (total)	580.0	
	Vinyl chloride	88.0	
11GI1402	cis-1,2-dichloroethene	240.0	D
	Vinyl chloride	33.0	

Table 8-1
Site 11 FPDWS Criteria Exceedances, Phases I and II

Sample ID	Parameter	Result (μg/L)	
11GI1501	Arsenic	230.0	
	Beryllium	11.0	
	Chromium	771.0	
	Lead	94.0	J
	Nickel	512.0	
11GLF0100	Arsenic	135.0	
	Beryllium	7.4	
	Cadmium	275.0	
	Chromium	872.0	
	Lead	5060.0	
	Nickel	177.0	
	Silver	6.1	J
11GLF1000	4,4'-DDD	0.14	J
	Antimony	21.0	J
	Arsenic	148.0	
	Barium	2170.0	
	Beryllium	22.5	
	Cadmium	4990.0	
	Chromium	2290.0	
	Lead	50200.0	
	Mercury	5.9	
	Nickel	715.0	
	Silver	9.2	
11GLF1100	Arsenic	80.2	J
	Benzene	2.0	J
	Beryllium	4.3	J
	Cadmium	47.9	
	Chromium	1190.0	
	Lead	803.0	
	Silver	5.8	
11GLF1200	2-methylnaphthalene	54.0	J
	Cadmium	169.0	
	Lead	21700.0	
	Naphthalene	69.0	J
	Trichloroethene	21.0	J

Table 8-1
Site 11 FPDWS Criteria Exceedances, Phases I and II

Sample ID	Parameter	Result (μg/L)	
11GLF1300	1,1,2,2-tetrachloroethane	15.0	J
	Arsenic	128.0	J
	Barium	2710.0	
	Cadmium	236.0	
	Chromium	261.0	
	Lead	11600.0	
	Nickel	145.0	
11GS0102	Cadmium	8.0	
11GS0301	Aldrin	0.0	J
	Dieldrin	0.0094	J
11GS0501	Lead	30.0	J
	Trichloroethene	4.0	J
11GS0701	Cadmium	7.0	
11GS1301	Barium	3790.0	
	Lead	17.0	
11GS1302	Tetrachloroethene	7.0	J
	Trichloroethene	5.0	J
	Vinyl chloride	3.0	J

Notes:
J = Detected concentration is estimated.
D = Detected concentration was obtained from a diluted sample.
μg/L = micrograms per Liter.
Sample IDs ending in 00 or 01 indicate Phase I sampling results; sample IDs ending in 02 or 03 indicate Phase II sampling results.
Compound-specific criteria are provided in Appendix C.

Comparison with Freshwater Surface Water Quality

Phase I

Fourteen of 15 shallow and eight out of nine intermediate well locations had samples in which contaminants exceeded at least one FSWQ. However, only three of four shallow wells that border freshwater bodies had exceedances of any FSWQs when secondary metals were excluded. Contaminants that exceeded criteria are barium, TCE, heptachlor epoxide, and BEHP (a common laboratory artifact). Affected wells 11GM52 and 11GS13 are adjacent to each other along the freshwater creek in the southern portion of the site; however, they do not have similar contaminants.

Only three of five intermediate wells that border freshwater bodies had exceedances of FSWQs when secondary metals were excluded. Contaminants that exceeded their criteria are primary metals (arsenic, beryllium, and selenium), VOCs (1,2-DCA and TCE), and 4,4'-DDD.

All of the water samples collected from temporary exploratory trenches exceeded at least one FSWQs However, the exceedances are not considered because the trenches were not adjacent to any freshwater bodies and they are not representative of the aquifer.

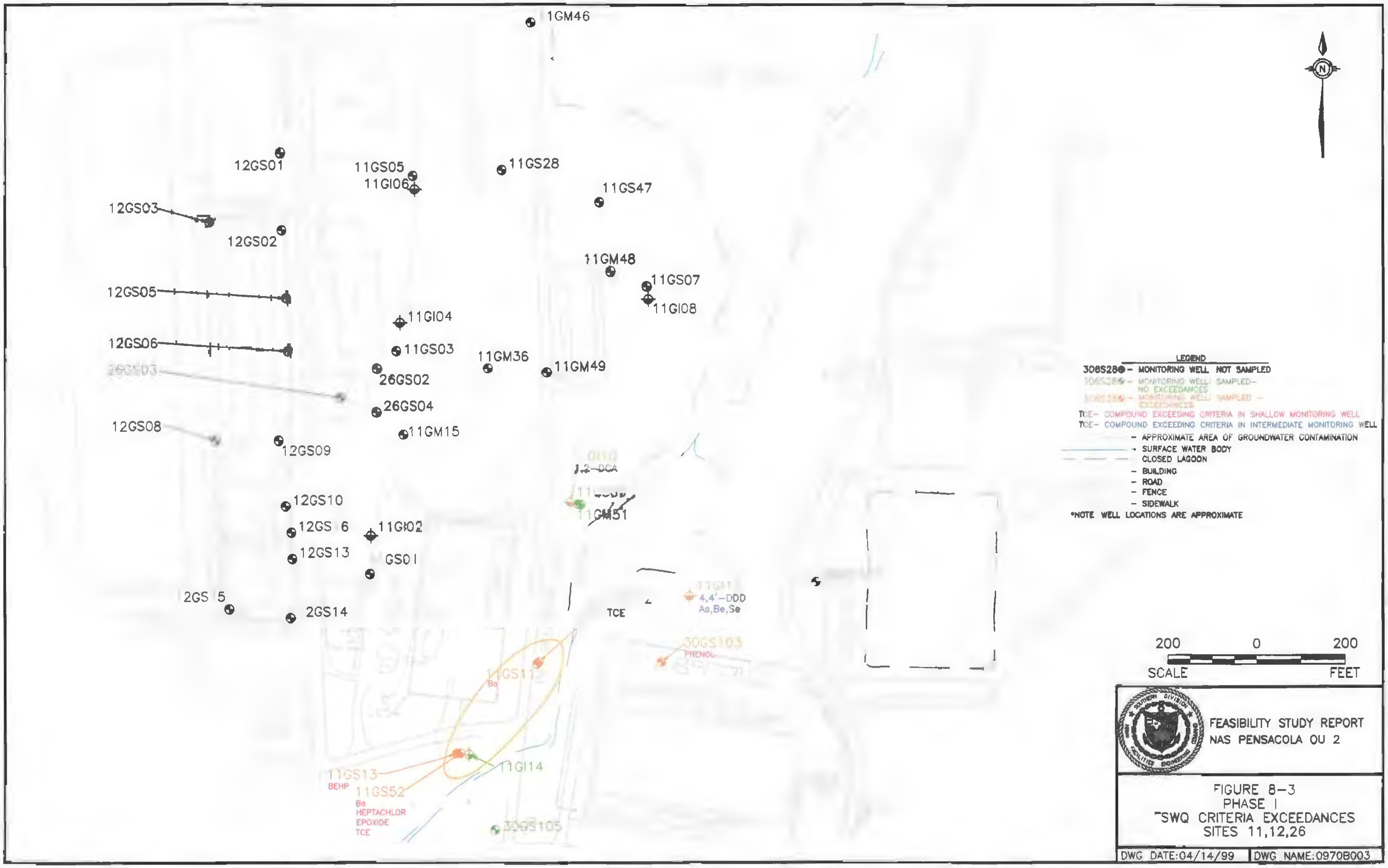
Site 11 wells exceeding FSWQ criteria during Phase I are shown on Figure 8 3

Phase II

Samples from seven of eight shallow and three of four intermediate well locations had contaminants that exceeded at least one FSWQ. However, only two of three shallow wells that border freshwater bodies had exceedances of any FSWQ when secondary metals are excluded. VOC contaminated wells 11GM52 (1,1-DCE, tetrachloroethene, and TCE) and 11GS13 (tetrachloroethene and TCE) are adjacent to each other along the freshwater creek in the southern portion of the site

Only one of two intermediate wells that border freshwater bodies had exceedances of any FSWQs. TCE's FSWQ was exceeded at well 11GI12.

Wells 11GI12, 11GS13, and 11GS52 in the southern portion of Site 11, were contaminated with VOCs. However, since sediment samples collected from Wetland 64 did not contain 1,1-DCE, tetrachloroethene, or TCE and nearby "upgradient" wells had no similar VOC exceedances,



FEASIBILITY STUDY REPORT
NAS PENSACOLA OU 2

FIGURE 8-3
PHASE I
FSWQ CRITERIA EXCEEDANCES
SITES 11,12,26

DWG DATE:04/14/99 | DWG NAME:0970B003

Site 11 is not considered a primary source of wetland contamination. The Site 41 RI indicated that the primary contributor to wetlands contamination may be current and historical storm water runoff, not groundwater infiltration. As discussed previously, Site 11 soil and groundwater are not considered a potential threat to adjacent water bodies.

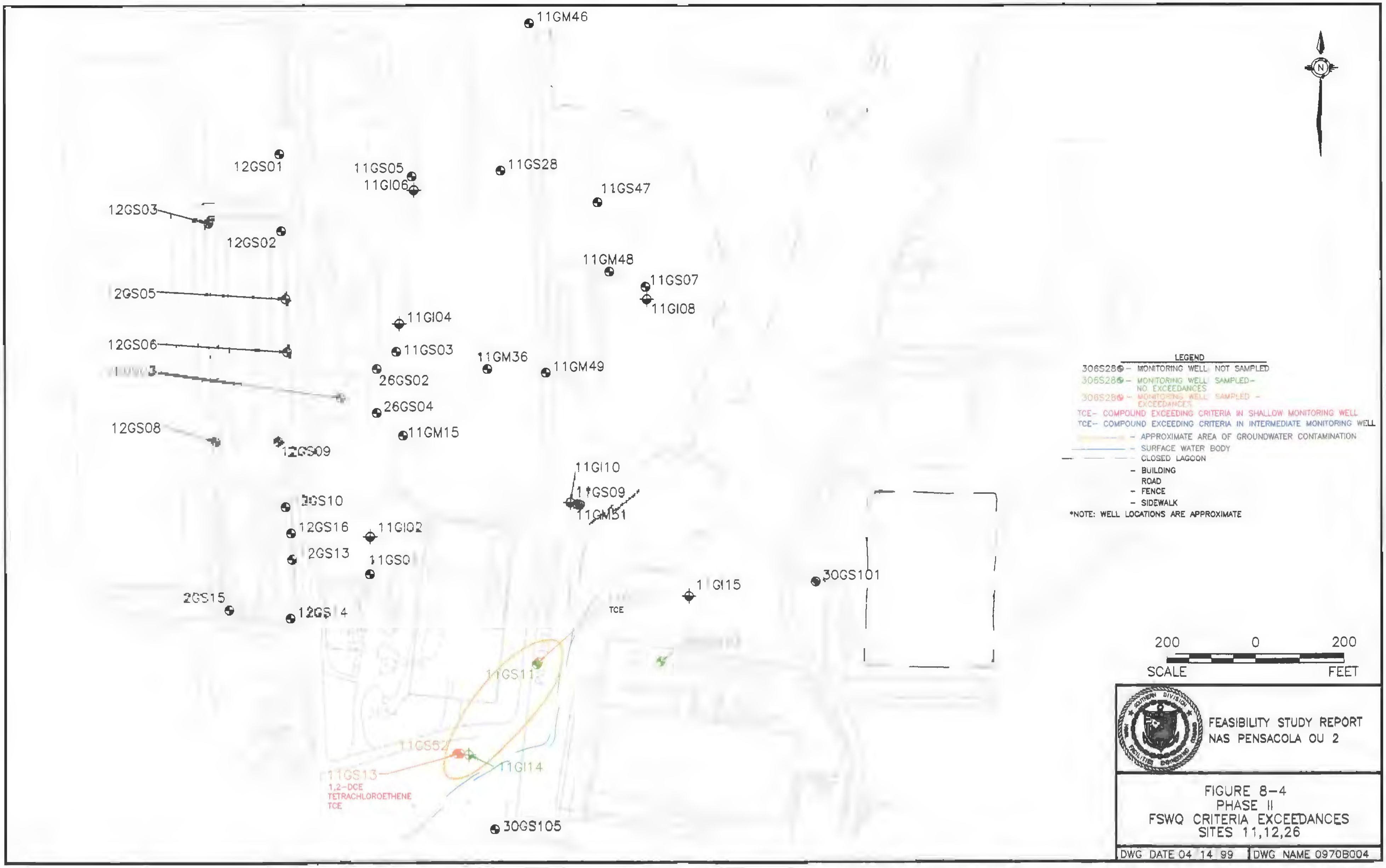
Site 11 wells in which samples exceeded FSWQ criteria during Phase II are shown on Figure 8-4.

Table 8-2 lists the compounds that exceed FSWQs in wells that border freshwater bodies.

Table 8-2
Site 11 Freshwater Surface Water Quality Exceedances, Phases I and II

Sample ID	Parameter	Result (µg/L)	
11GS5201	Heptachlor epoxide	0.0059	J
	Trichloroethene	20.0	J
11GS5202	1,1-dichloroethene	10.0	
	Tetrachloroethene	23.0	
	Trichloroethene	50.0	
11GI1001	1,2-dichloroethane	9.0	J
11GI1201	Trichloroethene	14.0	
11GI1202	Trichloroethene	11.0	J
11GI1501	4,4'-DDD	0.07	J
	Arsenic	230.0	
	Beryllium	11.0	
	Selenium	11.5	
11GS1101	Barium	1520.0	
11GS1301	Barium	3790.0	
	BEHP	1.0	J
11GS1302	Tetrachloroethene	7.0	J
	Trichloroethene	5.0	J

Notes:
J = Detected concentration is estimated.
µg/L = micrograms per Liter.
Sample IDs ending in 00 or 01 indicate Phase I sampling results; sample IDs ending in 02 or 03 indicate Phase II sampling results.
Compound-specific criteria are provided in Appendix C.


11GM46
12GS01
11GS05
11GI06
11GS28
11GS47
12GS03
12GS02
11GM48
11GS07
11GI08
11GI04
11GS03
11GM36
11GM49
12GS06
26GS02
26GS04
11GM15
12GS08
12GS09
11GI10
11GS09
11GM51
12GS16
11GI02
12GS15
12GS14
11GI15
30GS101
TCE
11GS11
11GS52
11GS13
1,2-DCE
TETRACHLOROETHENE
TCE
11GI14
30GS105
LEGEND
MONITORING WELL NOT SAMPLED
MONITORING WELL SAMPLED-NO EXCEEDANCES
MONITORING WELL SAMPLED-EXCEEDANCES
TCE- COMPOUND EXCEEDING CRITERIA IN SHALLOW MONITORING WELL
TCE- COMPOUND EXCEEDING CRITERIA IN INTERMEDIATE MONITORING WELL
APPROXIMATE AREA OF GROUNDWATER CONTAMINATION
SURFACE WATER BODY
CLOSED LAGOON
BUILDING
ROAD
FENCE
SIDEWALK
*NOTE: WELL LOCATIONS ARE APPROXIMATE
200 0 200
SCALE FEET
FEASIBILITY STUDY REPORT
NAS PENSACOLA OU 2
FIGURE 8-4
PHASE II
FSWQ CRITERIA EXCEEDANCES
SITES 11,12,26
DWG DATE 04 14 99
DWG NAME 0970B004

Comparison with Marine Surface Water Quality

Phase I

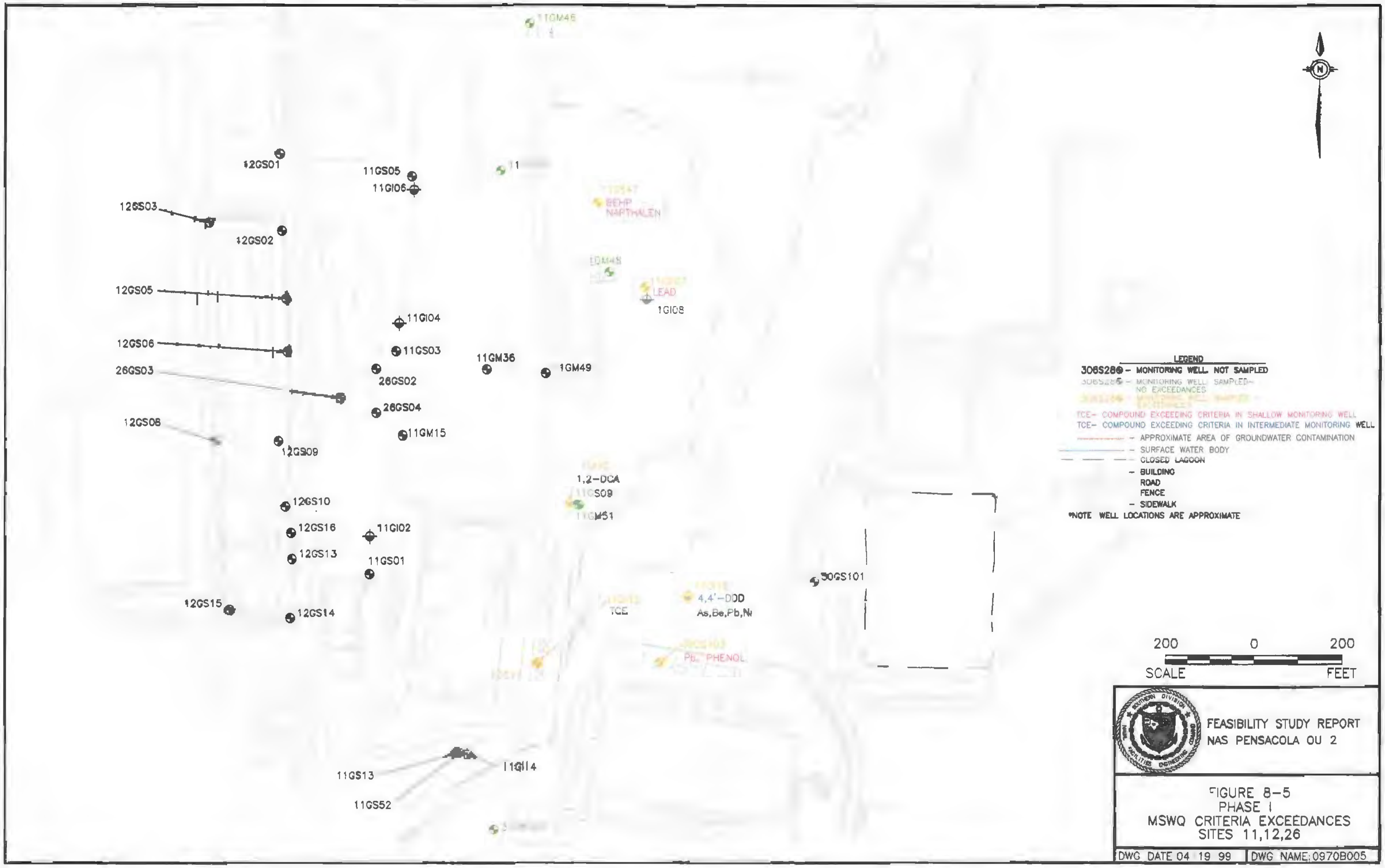
Contaminants exceeded at least one MSWQ in samples from 14 of 15 shallow wells and every intermediate well. However, only two of five shallow wells (11GS47 and 11GS07) that border saltwater bodies had any MSWQ exceedances when secondary metals were excluded. The contaminants that exceeded MSWQ criteria were lead, napthalene, and BEHP. Contaminated wells 11GS47 and 11GS07 are both along the Yacht Basin's western shore; however, they did not have similar contaminants.

Only three of five intermediate wells that border saltwater bodies had any MSWQ exceedances when secondary metals were excluded The contaminants that exceeded MSWQ criteria were primary metals (arsenic, beryllium, and led), VOCs (1 2-DCA and TCE), and 4-4'-DDD. The affected wells do not have similar exceedances, which suggests that there is no large contaminant mass-plume in either the shallow or intermediate zone which may threaten nearby saltwater bodies

All of the water samples collected from temporary exploratory trenches exceeded at least one MSWQs. However, the trenches were not adjacent to any saltwater bodies and are not representative of the aquifer. As a result, the exceedances are not considered. Site 11 wells in which samples exceeded MSWQ criteria during Phase I are shown on Figure 8-5.

Phase II

Contaminants exceeded at least one MSWQ in seven of eight shallow wells and three of four intermediate wells. However, only one shallow well (11GM47) that borders saltwater bodies had any FSWQ exceedances when secondary metals were excluded. The contaminants that exceeded MSWQ criteria were lead, mercury, benzene, 2-methylnapthalene, and napthalene; only napthalene exceeded its MSWQ during both sampling phases. Well 11GM47 is in the northwestern portion of the site. Wetland Site 64 sediment sample 041M64005 (nearest to well 11GM47) contained trace amounts of napthalene, lead, and mercury resulting in HQs of 2.05.


11GM46
12GS01
11GS05
11GI06
12GS03
12GS02
BEHP
NAPTHALEN
12GS05
LEAD
1GI08
11GI04
12GS06
11GS03
11GM36
1GM49
26GS03
26GS02
26GS04
12GS08
11GM15
12GS09
1,2-DCA
11GS09
12GS10
11GM51
12GS16
11GI02
12GS13
11GS01
30GS101
4,4'-DDD
As,Be,Pb,Ni
12GS15
12GS14
TCE
Pb, PHENOL
11GS13
11GI14
11GS52
LEGEND
306S28 - MONITORING WELL NOT SAMPLED
306S28 - MONITORING WELL SAMPLED-
NO EXCEEDANCES
TCE- COMPOUND EXCEEDING CRITERIA IN SHALLOW MONITORING WELL
TCE- COMPOUND EXCEEDING CRITERIA IN INTERMEDIATE MONITORING WELL
- APPROXIMATE AREA OF GROUNDWATER CONTAMINATION
- SURFACE WATER BODY
- CLOSED LAGOON
- BUILDING
ROAD
FENCE
- SIDEWALK
*NOTE WELL LOCATIONS ARE APPROXIMATE
200
0
200
SCALE
FEET
FEASIBILITY STUDY REPORT
NAS PENSACOLA OU 2
FIGURE 8-5
PHASE I
MSWQ CRITERIA EXCEEDANCES
SITES 11,12,26
DWG DATE 04 19 99
DWG NAME: 0970B005

8 86, and 2.08, respectively. In addition, Wetland 64 surface water sample 041W640501 contained lead and mercury resulting in HQs of 1.01 and 2.40, respectively.

Only one well that borders saltwater bodies (11GI12) had any MSWQ exceedances when secondary metals are excluded. Contaminants included TCE along the creek just south of the Yacht Basin's mouth in the southern portion of the site. Phase II results affirmed the presence of TCE in intermediate well 11GI12. However, sediment samples from Wetland 64 did not contain TCE and nearby upgradient wells did not contain VOC exceedances. No surface water samples were collected near well 11GI12. Site 11 wells, in which samples exceeded MSWQ criteria during Phase II sampling are shown on Figure 8-6.

Based on Phase I and II sampling, Site 11 is not a primary wetland contamination source. The Site 41 RI indicated that the primary contributor to wetlands contamination is likely current and historical storm water runoff, no groundwater infiltration. As discussed previously, Site 11 soil and groundwater are not considered a potential threat to adjacent water bodies Table 8 3 lists the compounds that exceed MSWQ criteria in wells that border saltwater bodies

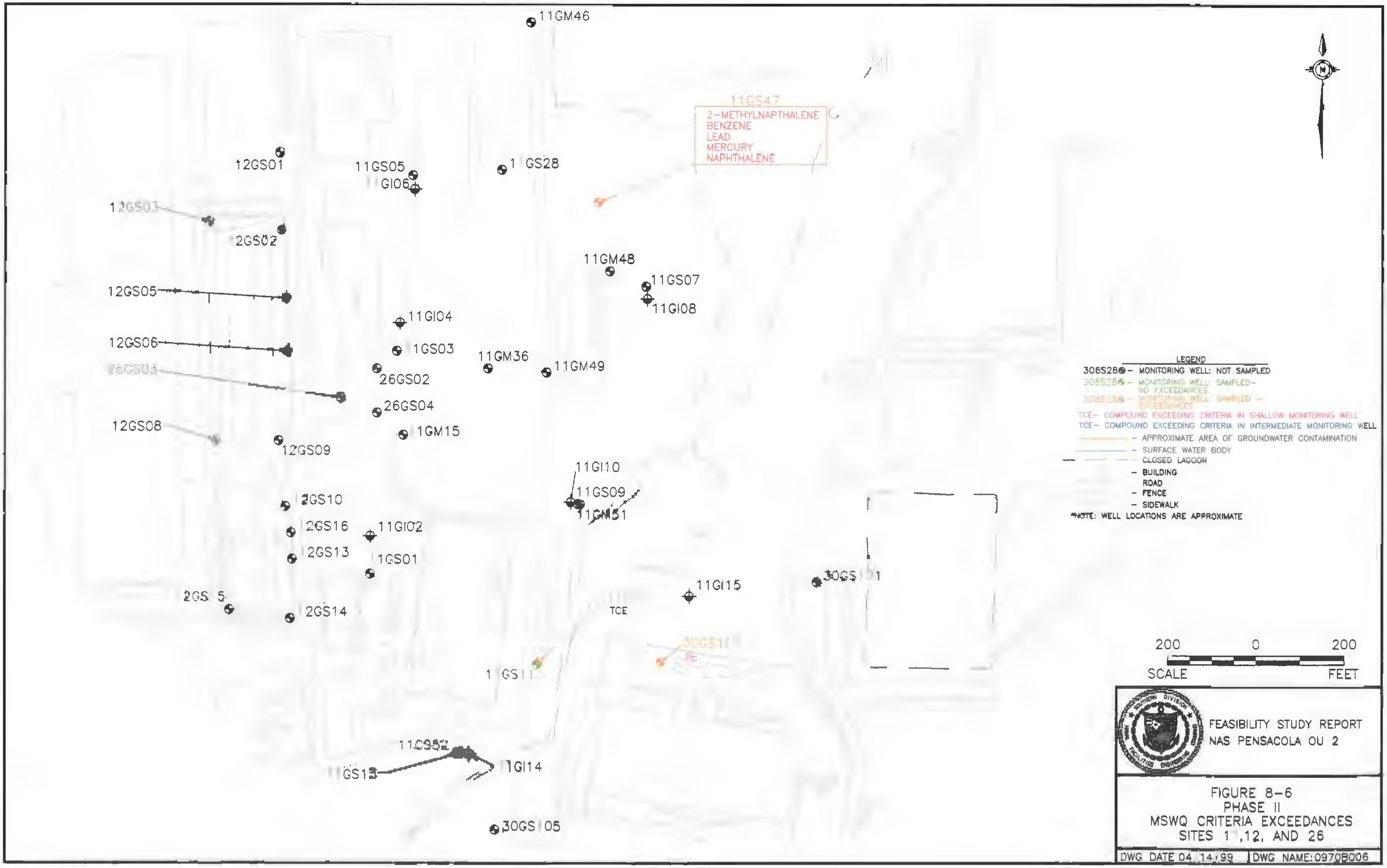


FIGURE 8-6
PHASE II
MSWQ CRITERIA EXCEEDANCES
SITES 1 ,12, AND 26

DWG DATE 04 14 99 | DWG NAME:0970B006

Table 8-3
Site 11 Marine Surface Water Quality Exceedances, Phases I and II

Sample ID	Parameter	Result (µg/L)	
11GS4701	BEHP	2.0	J
	Naphthalene	47.0	
11GS4702	2-methylnaphthalene	40.0	
	Benzene	3.0	
	Lead	1710.0	
	Mercury	0.1	J
	Naphthalene	60.0	
11GI1001	1,2-dichloroethane	9.0	J
11GI1201	Trichloroethene	14.0	
11GI1202	Trichloroethene	11.0	J
11GI1501	4,4'-DDD	0.07	J
	Arsenic	230.0	
	Beryllium	11.0	
	Lead	94.0	J
	Nickel	512.0	
11GS0701	Lead	6.0	

Notes:
J = Detected concentration is estimated.
µg/L = micrograms per Liter.
Sample IDs ending in 00 or 01 indicate Phase I sampling results; sample IDs ending in 02 or 03 indicate Phase II sampling results.
Compound-specific criteria are provided in Appendix C.

Comparison with Groundwater of PQG Criteria

Phase I

Contaminants exceeded PQG criteria in 13 of 15 shallow wells and every intermediate well,. However, only two of the 15 shallow wells had any exceedances when secondary metals were excluded. The only contaminant exceeding PQG criteria was vinyl chloride. Contaminated wells 11GM47 and 11GM52 are located on opposite ends of Site 11 and intervening wells do not appear to be contaminated with vinyl chloride. Consequently, these exceedances do not suggest the presence of a significant contaminant plume.

Only one of nine intermediate wells (11GI14) had any PQG exceedance when secondary metals were excluded. The only exceedance was for vinyl chloride. Well 11GI14 is adjacent to well 11GM52, confirming the presence of vinyl chloride at this location in the site's southern portion.

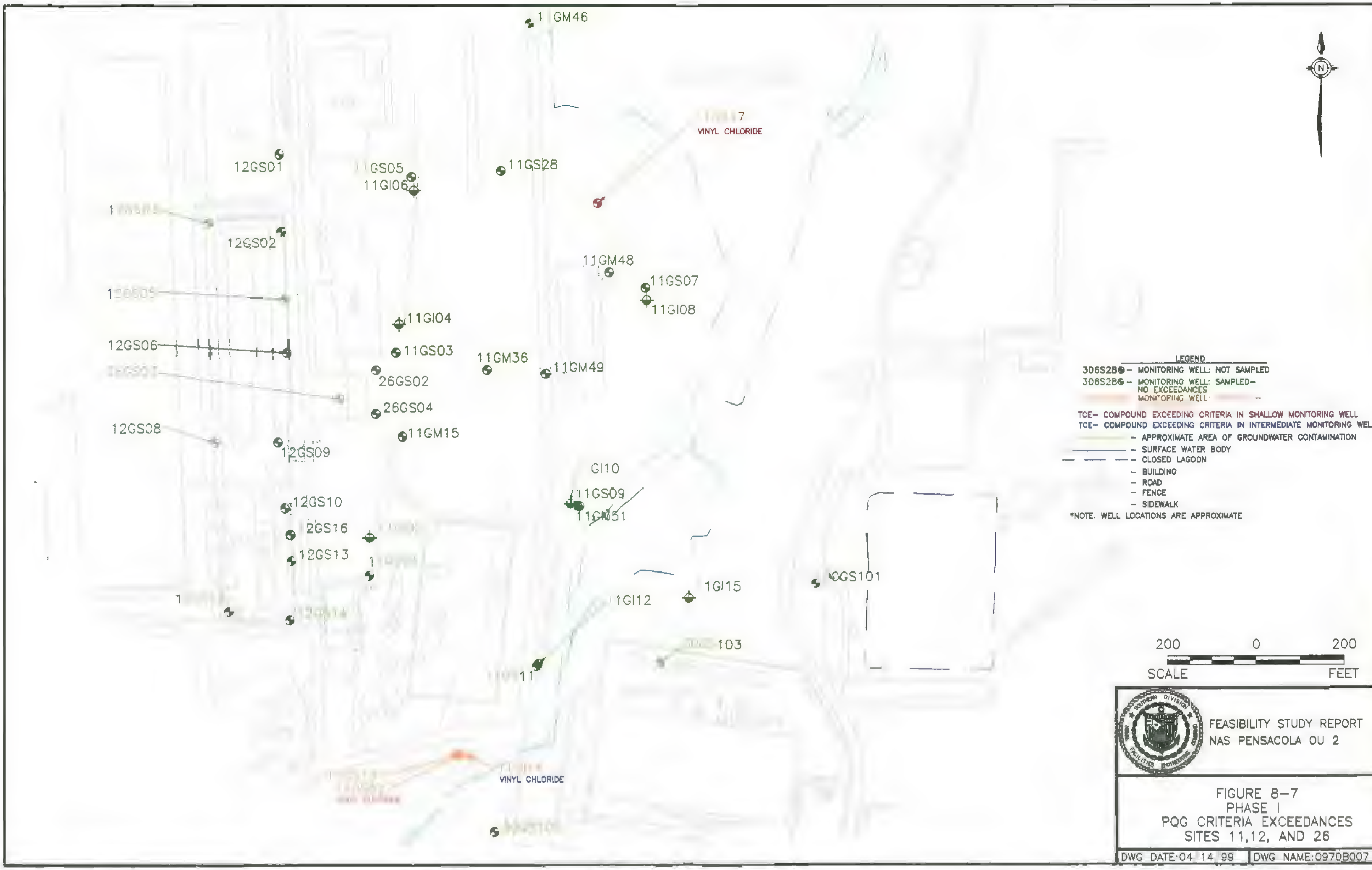
All of the water samples collected from temporary exploratory trenches exceeded at least one PQG criteria. However, the trench water contamination may be from sediment rather than groundwater since the samples had high levels of turbidity and the trenches do not indicate actual aquifer conditions. Contaminants that exceeded criteria were metals, further evidence that entrained sediment in the water samples may have caused the exceedances.

Site 11 wells in which samples exceeded PQG criteria during Phase I sampling are shown on Figure 8-7

Phase II

Contaminants exceeded PQG criterion in six of eight shallow wells and every intermediate well. However, only six of eight shallow wells had any groundwater exceedances when secondary metals were excluded. Contaminants that exceeded criteria are lead, 1,2-DCE, TCE, and vinyl chloride. VOC exceedances at 11GM52 and 11GS47 confirm Phase I sampling results. Contaminated wells 11GM47 and 11GM52 are located on opposite ends of Site 11 and intervening wells do not appear to be contaminated with vinyl chloride.

In samples from one of four intermediate wells (11G114) only one contaminant exceeded at least one PQG criteria — vinyl chloride. Phase II results confirmed the presence of vinyl chloride in intermediate well 11GI14 detected during Phase I sampling



FEASIBILITY STUDY REPORT
NAS PENSACOLA OU 2

FIGURE 8-7
PHASE I
PQG CRITERIA EXCEEDANCES
SITES 11,12, AND 26

DWG DATE 04 14 99 | DWG NAME:0970B007

Well 11GS47 and adjacent wells 11GI14 and 11GM52 were contaminated with VOCs during Phase I and II sampling events. However, since VOC contamination was not identified in upgradient wells contamination, in these three wells may be from past localized activities.

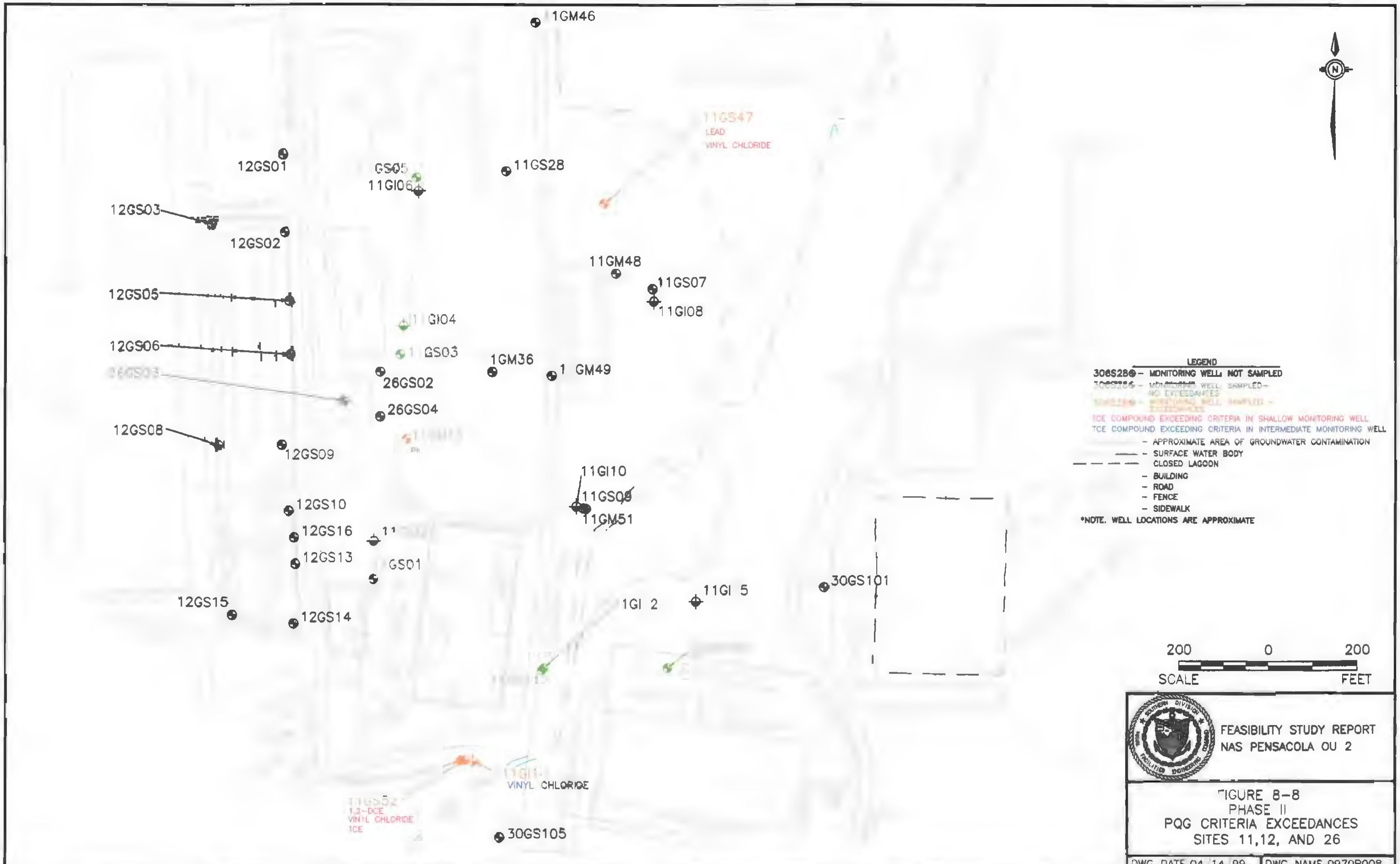
Site 11 wells in which samples exceeded PQG criteria during Phase II are shown on Figure 8-8.

Table 8-4 lists the PQG exceedances.

Table 8-4
Site 11 PQG Criteria Exceedances, Phases I and II

Sample ID	Parameter	Result (μg/L)	
11GS1503	Lead	3500.0	
11GS4701	Vinyl chloride	55.0	
11GS4702	Lead	1710.0	
	Vinyl chloride	48.0	D
11GS5201	Vinyl chloride	230.0	
11GS5202	cis-1,2-dichloroethene	970.0	D
	Trichloroethene	50.0	
	Vinyl chloride	74.0	D
11GI1401	Vinyl chloride	88.0	
11GI1402	Vinyl chloride	33.0	
11GLF0100	Cadmium	275.0	
	Lead	5060.0	
	Silver	6.1	J
11GLF1000	Antimony	210.0	
	Cadmium	4990.0	
	Chromium	2290.0	
	Lead	50200.0	
	Silver	9.2	J
11GLF1100	Chromium	1190.0	
	Lead	803.0	
	Silver	5.8	J
11GLF1200	Cadmium	169.0	
	Lead	21700.0	
11GLF1300	1,1,2,2-tetrachloroethane	15.0	J
	Cadmium	236.0	
	Lead	11600.0	

Notes:
D = Detected concentration was obtained from a diluted sample.
J = Detected concentration is estimated.
μg/L = micrograms per Liter.
Sample IDs ending in 00 or 01 indicate Phase I sampling results; sample IDs ending in 02 or 03 indicate Phase II sampling results.
Compound-specific criteria are provided in Appendix C.



FEASIBILITY STUDY REPORT
NAS PENSACOLA OU 2

FIGURE 8-8
PHASE II
PQG CRITERIA EXCEEDANCES
SITES 11,12, AND 26

DWG DATE 04/14/99 | DWG NAME 0970B008

8.1.2 Site 12 ARAR Exceedances

Comparison with FPDWS and FSDWS Criteria

Site 12 wells were only sampled during Phase I. Contaminants exceeded at least one groundwater criteria in eight of 12 shallow wells. However, only six of the wells had any exceedances when secondary metals were excluded. Contaminants exceeding criteria were cadmium, dieldrin, and 4,4'-DDD. Dieldrin was detected in several wells in the northern portion of the site at concentrations exceeding FPDWS criteria. Cadmium and 4,4'-DDD exceedances were detected in one well (12GS08) in the western portion of the site.

There are no intermediate wells at Site 12.

Site 12 wells in which contaminants exceeded FPDWS criteria during Phase I are shown in Figure 8-1.

Table 8-5 lists the FPDWS criteria exceedances.

Table 8-5
Site 12 FPDWS Criteria Exceedances, Phases I and II

Sample ID	Parameter	Result (μg/L)	
12GS0101	Dieldrin	0.0073	J
12GS0201	Dieldrin	0.0720	J
12GS0301	Dieldrin	0.300	
12GS0501	Dieldrin	0.068	J
12GS0601	Dieldrin	0.074	J
12GS0801	4,4'-DDD	0.110	
	Cadmium	9.6	

Notes:
J = Detected concentration is estimated.
μg/L = micrograms per Liter.
Sample IDs ending in 00 or 01 indicate Phase I sampling results; sample IDs ending in 02 or 03 indicate Phase II sampling results.
Compound-specific criteria are provided in Appendix C.

Comparison with Freshwater Surface Water Quality

Because Site 12 is not adjacent to any freshwater body, contaminants in the shallow aquifer do not threaten any nearby surface water.

Comparison with Marine Surface Water Quality (MSWQ)

Because Site 12 is not adjacent to any saltwater body, contaminants in the shallow aquifer do not threaten any nearby surface water.

Comparison with Groundwater of PQG Criteria

None of the shallow well locations exceeded PQG criteria

8.1.3 Site 26 ARAR Exceedances

Comparison with FPDWS and FSDWS Criteria

Site 26 wells were only sampled during Phase I Contaminants exceeded at least one FPDWS and FSDWS criteria in three of four shallow wells However only two of the shallow wells had any exceedances when secondary metals were excluded. The contaminants that exceeded their criteria were antimony, cadmium, and dieldrin. Dieldrin exceeded its criterion in well 26GS03 and 26GS04 in the site's northern portion. These exceedances were consistent with Site 12 sampling results. Cadmium and antimony exceeded their criteria in only one well (26GS03), also in the northern portion of the site.

There are no intermediate wells at Site 26.

Site 26 wells in which contaminants exceeded FPDWS criteria during Phase I are shown on Figure 8-1.

Table 8-6 lists FPDWS criteria exceedances.

Table 8-6
Site 26 FPDWS Criteria Exceedances, Phases I and II

Sample ID	Parameter	Result (μg/L)	
26GS0301	Antimony	20.2	J
	Cadmium	6.2	J
	Dieldrin	0.026	
26GS0401	Dieldrin	0.007	J

Notes:
J = Detected concentration is estimated.
μg/L = micrograms per Liter.
Sample IDs ending in 00 or 01 indicate Phase I sampling results; sample IDs ending in 02 or 03 indicate Phase II sampling results.
Compound-specific criteria are provided in Appendix C.

Comparison with Freshwater Surface Water Quality

Because Site 26 is not adjacent to any freshwater body, contaminants in the shallow aquifer do not threaten any nearby surface water.

Comparison with Marine Surface Water Quality

Because Site 26 is not adjacent to any saltwater body, contaminants in the shallow aquifer do not threaten any nearby surface water.

Comparison with Groundwater of PQG Criteria

None of the shallow wells had PQG criteria exceedances.

8.2 Remedial Goals

As discussed in Section 1.3.3, background water quality exceeds FSDWS; therefore, the aquifer is considered a poor quality aquifer. Table 8-7 presents chemicals of concern and their groundwater RGs at Site OU 2 based on poor quality groundwater conditions and the designation of this site as an industrial area.

Table 8-7
Contaminant-Specific Remediation Goals for Groundwater at OU 2

Contaminant	RG (μg/L)
Antimony	60
Cadmium	50
Chromium	1000
Lead	150
Silver	1000
Heptachlor epoxide	4
bis-(2-ethylhexyl)phthalate	60
1,3-dichlorobenzene	100
4-methylphenol (p-cresol)	40
Naphthalene	200
Phenol	100
Benzene	10
Chloroethene	120
1,1-DCA	700
1,2-DCA	30
1,1-DCE	70
cis-1,2-DCE	700
1,1,2,2-tetrachloroethane	2
Tetrachloroethylene (PCE)	30
1,1,1-trichloroethane	2000
Trichloroethylene (TCE)	30
Vinyl chloride	10

Note:
μg/L = micrograms per Liter.

To assess whether the remedial goals for the contaminants at OU 2 are appropriate, the following were considered:

- *The effectiveness of completed source removal actions* — There have been no source removal actions. However, because there are no current groundwater exposure pathways and nearby surface waters have not be affected by groundwater contaminant migration, source controls or removal actions have not been warranted.

- *The practical likelihood that low yield or poor quality groundwater and groundwater near marine surface water bodies would be used for drinking water* — Due to the abundant supply of high quality water in the deeper main producing zone groundwater from the surficial zone is not used as a potable water source in southern Escambia County, nor is it expected to be used in the future

- *The current and projected use of groundwater in the vicinity of the site and in the immediate vicinity of the contaminated area* — The base receives its potable water from Corry Station, which is approximately three miles away.

- *Whether groundwater contamination is migrating* — As discussed in Section 8.1, there no evidence that groundwater contamination is migrating.

- *Whether human health, public safety, and the environment could be protected using institutional controls* — The consumption of contaminated groundwater would be controlled institutionally and groundwater would be monitored until remedial goals are met. In addition, controls currently in place at the site which include military security and limited site access and use — would remain.

Based on this assessment, groundwater RGs are GW-PQG criteria. Institutional controls are required with poor quality groundwater classification — as such, all remedial alternatives will include costs for instituting groundwater use restrictions and other site controls.

8.3 Groundwater Volumes

Sites 11, 12 and 26 constitute OU 2's northern portion. Groundwater typically flows east from Site 12 and discharges to surface water bodies (Wetland 64 and Bayou Grande). Site 30 wells 30GS101, 30GS103 and 30GS105 have also been installed in this area; these wells are east of the surface water bodies and presumably discharge to the west.

These grouped sites share the following environmental issues

- Metals — Low-flow sampling techniques used during Phase II may have contributed to fewer metals exceedances by significantly reducing turbidity in the shallow and intermediate well samples However even though remediation may not be required for inorganics they will impact remedial design due to operational considerations (e.g precipitation and fouling). During Phase II sampling, contamination in 11GS47 and 11GM15 exceeded PQG lead criteria.

- **VOCs** — VOCs tend to concentrate along the freshwater creek in wells 11GI12, 11GS13, 11GI14, and 11GS52 in the southern portion of the site and in well 11GS47 to the north. Because VOCs have not been identified in the upgradient wells, contamination in these wells may be from past localized activities.

- **SVOCs** — Contaminants exceeded FPDWS criteria in only one well (30GS47).

- **Pesticides/PCBs** — Phase I sampling identified dieldrin contamination in Sites 12 and 26. However, concentrations did not exceed limits for PQG criteria at any well.

Because contaminants exceed groundwater RG only at 11GS47, 11GM15, and 11GS52/11GI14, no plume is thought to be continuous across the site. Calculation of the volume of impacted groundwater assumes a porosity of 30%, an aquifer thickness of 40 feet (i.e., that contamination is present through the entire aquifer), and that contamination extends halfway to the nearest well. Impacted volumes are shown in Table 8-8 below; impacted areas are shown on Figure 8-8.

Table 8-8
Sites 11, 12, and 26 – Groundwater Volumes Exceeding RGs

Impacted Wells	Contaminants	Nearest Well	Impacted Radius	Impacted Volume
11GS47	Lead Vinyl Chloride	11GM48	80 feet	241,000 ft^3 1.8 million gallons
11GM15	Lead	26GS04	40 feet	60,000 ft^3 451,000 gallons
11GS52/11GI14	cis-1,2-DCE Vinyl Chloride TCE	30GS105	90 feet	305,000 ft^3 2.3 million gallons

Note:
Ft^3 = Cubic Feet

8.4 Identification and Screening of Technologies

This section describes the initial steps toward remedy selection: identification and screening of applicable technologies. After technologies are identified, they are reviewed for effectiveness, implementability, and cost. These criteria are discussed in Section 2.2.6. Based on this screening, technologies are either eliminated from further consideration or retained for further consideration. Alternatives for remedial action for Sites 11, 12, and 26 at OU 2 will be developed from the technologies retained.

Each treatment technology's objective, implementability, effectiveness, and cost are discussed in Table 8-9. They are consistent with technology-screening techniques presented in the NCP and USEPA guidance because they include containment, removal, disposal, and treatment options.

Technology Screening Results

Implementability, effectiveness, and cost were used to screen the technologies and to draw the following conclusions. The following technologies were all screened from further consideration.

- **Air Sparging** was screened from further consideration due to potential complications from inorganic oxidation. SVE which is required to contain the off-gas, would likely be compromised from short circuiting due to the shallow depth to groundwater. The shallow water table limits this technology's effectiveness because it is difficult to control gases and vapor in the subsurface The vadose zone should extend at least 10 feet below the ground surface to provide enough soil for SVE to be an effective approach to treat contaminants in soil

- **Chemical Oxidation** was screened from further consideration for the following reasons:

  — Metal ions may cause process fouling.

  — Treatment may result in the formation of intermediates that may be more toxic than the original compounds; additional time and money may be required to determine the intermediates composition.

  — Handling and storage of oxidizers may present safety problems and/or issues.

Table 8-9
Technology Screening for OU 2 Groundwater

Technology	Description	Implementability	Effectiveness	Cost
In situ Groundwater Treatment				
Air Sparging • natural gas injection • biosparging	Air is injected into the aquifer to strip contaminants from the water via volatilization. Air sparging is usually operated in conjunction with a soil vapor extraction (SVE) system to capture the gases stripped from the water. Gases must be treated prior to release. Adding natural gas to the air stream may stimulate naturally occurring microbes to degrade and remove chlorinated solvents in groundwater. Similarly, air injected at a lower flow rate can be used to enhance biological activity.	Air sparging is implementable at OU 2. The paved areas of the site would help contain any gases produced; however, it could also increase the possibility of gas migrating to nearby buildings. The water table should be deeper than 5 feet below ground surface. An air sparging system would require integration with an SVE unit.	Air Sparging is effective at removing VOCs and fuel hydrocarbons from the groundwater. SVOC effectiveness varies with the specific compound. Air sparging does not effectively treat inorganics. An oxidized aquifer may result in precipitation or increased solubility of certain inorganic species (see Appendix B for compound-specific reactions to aquifer conditions).	Costs for air sparging vary with the specific methodology or modification employed at the site and whether extracted air requires additional treatment. An air sparging system can cost 40% less than traditional pump and treat technologies.
Chemical Oxidation	A contaminants oxidation state is increased while the reactant's is lowered The contaminants are detoxified by changing their chemical forms. For example, an organic molecule can be converted to carbon dioxide and water or to an intermediate product that may be less toxic than the original.	Chemical oxidation is implementable at OU 2. However, elevated inorganic concentrations in the poor quality groundwater may interfere with chlorinated VOC oxidation. This technology is typically used for source area remediation rather than to treat aqueous plumes.	This technology has been demonstrated to be effective in removing low concentrations of halogenated and nonhalogenated VOCs and SVOCs, PCBs, pesticides, cyanides, and volatile and nonvolatile metals. However, the process is nonselective; therefore, any oxidizable material reacts. The oxidizing agents must be well mixed with the contaminants to produce effective oxidation. An oxidized aquifer may result in precipitation or increased solubility of certain inorganic species (see Appendix B for compound-specific reactions to aquifer conditions).	Chemicals used to oxidize the contaminants can significantly increase the capital cost This technology tends to be more cost effective for high contaminant concentrations relative to traditional pump and treat systems. Maintenance requirements are minimal.

Table 8-9
Technology Screening for OU 2 Groundwater

Technology	Description	Implementability	Effectiveness	Cost
Electrokinetic Remediation	Heavy metals, radionuclides, and organic contaminants are separated from saturated or unsaturated soils, sludges, and sediments. A low-intensity direct electrical current is applied across electrode pairs that have been implanted in the ground on either side of the contaminated zone. Electrokinetic transport can be classified into distinct electrokinetic phenomena: (1) electrophoresis, (2) electroosmosis, and (3) electromigration. Positively charged species and water move toward the cathode, negatively charged species move toward the anode. The contaminants may be extracted and directed to a recovery system or deposited and stabilized at the electrode.	Electrokinetic remediation may not be implementable at OU 2. Since OU 2 is an industrial site, buried metallic conductors interfere with the process.	This technology treats heavy metal, radionuclide, and organic-contaminated GW. Pilot-scale studies have indicated removal rates of 99% or greater for TCE. The process is most effective when the CEC and the salinity are low.	The cost of electrokinetic remediation depends on specific chemical and hydraulic properties at the site. Energy consumption is directly proportional to contaminant migration rates. This technology is more cost effective for large areas of contamination.
Enhanced Biodegradation • nitrate enhancement • oxygen enhancement	Enhanced biodegradation introduces natural and engineered microorganisms or oxygen-release compounds into the aquifer to promote microbial growth and accelerate natural processes. Some common additives are hydrogen peroxide, air, oxygen, methane, Fenton's reagent, nitrates, and molasses.	Enhanced biodegradation is implementable at OU 2. Treatability studies are required prior to full-scale implementation. Chemical incompatibility and potential interactions between GW geochemistry and underground utilities (tanks, pipe, etc.) may also be limiting at this site.	Primarily treats nonhalogenated VOCs and SVOCs, and fuel hydrocarbons. The process can be engineered to increase its effectiveness on halogenated VOCs and SVOCs. It is ineffective in treating inorganics. In fact, it may be limited by the potential for iron and microbial fouling due to the addition of oxygen and increase in pH	Bioremediation costs are typically variable since process amendments are highly site specific. However, in situ bioremediation costs are typically lower than other in situ technologies. This option is not likely cost effective given the small volume of groundwater requiring treatment and the low concentrations.

Table 8-9
Technology Screening for OU 2 Groundwater

Technology	Description	Implementability	Effectiveness	Cost
Monitored Natural Attenuation	Natural subsurface processes such as dilution, dispersion, volatilization, biodegradation, adsorption, stabilization, and chemical reactions with subsurface materials are allowed to reduce contaminants to acceptable concentrations. Site conditions are managed to protect human health and the environment.	Monitored natural attenuation is implementable at OU 2. It requires modeling and evaluation of contaminant degradation rates to determine feasibility, and state and community acceptance must be obtained. Monitored natural attenuation should only be used in low-risk situations such as OU 2 since the aquifer is considered a poor quality groundwater source. Long-term modeling is required.	This technology can effectively treat nonhalogenated VOCs and SVOCs. It is less effective for treating halogenated VOCs and SVOCs. Biodegradation can be slow; however, given time, it is expected that the contaminants would naturally attenuate to concentrations below remedial goals. Models can be used to predict treatment time.	Most of costs associated with MNA are related to routine O&M, monitoring, and reporting. Capital costs might include monitoring well installation and baseline sampling activities.
Passive Reactive Barriers	Passive reactive barriers are installed, usually in trenches, across a contaminant plume's flow path. The treatment walls are constructed of a permeable material that reacts with or acts as a catalyst for contaminant reactions (precipitation, sorption, or degradation). The reactions involve transforming the contaminants into a less toxic or less mobile form. The walls may contain metal-based catalysts to degrade VOCs, chelators to immobilize metals, nutrients and oxygen to encourage bioremediation, or other agents.	Typically, passive reactive barriers are installed down to the bottom of the aquifer. The depth to the clay layer beneath OU 2 (40 to 65 ft) is near the limits of this technology, making implementation difficult. However, in certain cases a "hanging" barrier may be used if engineered to prevent contaminant underflow.	Passive reactive barriers are primarily designed to treat halogenated VOCs and SVOCs and inorganic compounds. They can also be used less effectively to treat nonhalogenated VOCs and SVOCs and fuel hydrocarbons. Long-term effectiveness is influenced by life span of reactive material; it may require periodic replacement. Secondary inorganics may be impacted by reaction media chemistry, precipitate out, and thus reduce wall effectiveness (I,e., it is non-selective)	Relatively high capital costs associated with barrier installation and testing. Very low O&M costs. However, PRBs require routine sampling and monitoring to measure its effectiveness. .
Phyto-remediation	Use of plants and their associated rhizospheric microorganisms to remove, contain, and/or degrade environmental contaminants in groundwater. Groundwater phytoremediation includes three processes: rhizofiltration, phytotransformation, and phytostimulation. Deep-rooted trees may affect (redirect or capture) groundwater flow and thus retard contaminant migration.	Phytoremediation is implementable at OU 2. Treatability studies are required prior to full-scale implementation. Plant species are selected based on: 1) GW evapotranspiration potential, 2) the ability to produce degradative enzymes, 3) contaminant bioaccumulation rate, 4) depth of the root zone, and 5) ability to adapt to the specific climate.	Phytoremediation is thought to be capable of treating a wide range of contaminants, including petroleum hydrocarbons, chlorinated solvents, pesticides, metals, radionuclides, explosives, and excess nutrients. However, because it is an emerging technology, limited data are available to evaluate its overall effectiveness. Contaminants are reduced over a long period of time (years). Limited to GW within 10 feet of the surface. (See note 1)	Costs for phytoremediation are expected to be relatively low compared to other in situ technologies. Maintenance costs are expected to be relatively low, consisting of monitoring, watering, and horticulture costs.

Table 8-9
Technology Screening for OU 2 Groundwater

Technology	Description	Implementability	Effectiveness	Cost
Ex situ Groundwater Technologies				
Bioreactors	A bioreactor treats extracted contaminated groundwater. Contaminants in groundwater contact microorganisms through attached or suspended biological systems. In suspended growth systems, such as activated sludge, contaminated groundwater circulates in an aeration basin, where a microbial population aerobically degrades organic matter In attached growth systems, such as trickling filters, microorganisms are established on an inert support matrix to aerobically degrade groundwater contaminants.	While implementable, a bioreactor is not technically practical at OU 2 due to the low contaminant concentration in the groundwater. This well developed technology has been used for many years to treat municipal wastewater. Equipment and materials are readily available.	Biological reactors can destroy organic contaminants. However, biochemical oxygen demand (BOD) loading must be high enough to support the growth of the microbes. The low level of organic contaminants present in OU 2 groundwater would not be sufficient to support the growth of microbes. Other treatment options are more effective.	Ex situ bioremediation technologies tend to be relatively expensive compared to in situ techniques due to controls and material handling requirements. This option is not likely cost effective due to low substrate concentrations in the groundwater.
Air Stripping	Air stripping can treat extracted contaminated groundwater at OU 2. Volatile organics are partitioned from water by greatly increasing the surface area of water exposed to air. Types of aeration methods include packed towers, diffused aeration, tray aeration, and spray aeration.	Air stripping is implementable at OU 2. Inorganics in groundwater may foul equipment or clog the stripping column packing material. If this occurs, the air stripper must be taken out of service and packing material acid-washed. Groundwater will likely require pretreatment (physical/chemical treatment) prior to air stripping to remove inorganics.	Air stripping is a proven technology that would be effective in reducing volatile contaminants to below remedial goals. SVOC contaminants would be reduced, but might not meet remedial goals. Air stripping is not effective in treating inorganics, and pretreatment (coagulation/precipitation/solids separation) must be implemented to avoid fouling.	Air stripping is moderately less expensive than other traditional pump and treat technologies. Capital costs include the column, piping, potential off-gas controls, and overall system controls. O&M costs increase if off-gas treatment is required.
Carbon Adsorption	Carbon adsorption can treat extracted contaminated groundwater at OU 2. Groundwater is pumped through canisters containing activated carbon to which dissolved contaminants adsorb.	Carbon adsorption is implementable at OU 2 Inorganics in groundwater may foul equipment or clog the carbon adsorption material Periodic replacement or regeneration of saturated carbon is required to prevent the effluent from exceeding remedial goals	Carbon adsorption is designed to treat halogenated and non-halogenated SVOCs. Because of carbon regeneration's high costs, carbon adsorption is sometimes used as a final polishing step with some other technology as the primary treatment.	Very high O&M costs associated with replacement and regeneration of spent carbon. Capital costs include the treatment tank, piping, and system controls

Table 8-9
Technology Screening for OU 2 Groundwater

Technology	Description	Implementability	Effectiveness	Cost
Coagulation/ precipitation and solids separation	Chemicals are added to extracted groundwater to form insoluble, agglomerated solids, with separation by settling or mechanical filtration.	Coagulation/precipitation is implementable at OU 2. As a result of separation technology, residuals are generated that require further treatment or disposal. Chemicals used for treatment can significantly increase the cost of this technology. This technology can be used as a pretreatment step prior to a primary treatment technology.	Coagulation/precipitation with solids separation is designed to treat inorganic compounds. It does not remove volatile and semivolatile organic compounds or fuel hydrocarbons effectively.	Chemicals used for treatment can significantly increase O&M costs. O&M cost also include pre- and post-treatment material handling. Capital costs are moderate compared to other traditional pump and treat systems.
Disposal	Groundwater is extracted and discharged to the FOTW where it is treated along with the sanitary sewage.	The FOTW can treat the groundwater generated at OU 2. The water must meet pretreatment standards prior to being accepted by the treatment works.	The FOTW should be able to achieve remedial goals for groundwater mixed with sanitary waste that is already being processed at the plant to acceptable discharge levels.	Costs increase if treatment is required
Membrane Filtration	Membrane filtration is a separation technology based on particle size. Contaminants are separated by forcing the fluid through a semipermeable membrane. Only particles smaller than the membrane openings can flow through.	Filtration is implementable at OU 2. As a result of separation technology, residuals are generated that require further treatment or disposal. This technology would likely be used as a pretreatment process prior to an organic remedial system.	This technology is used primarily to remove inorganics from waste streams, but can also be used to remove some organics.	Relatively expensive technology. Capital costs include the hydraulic and pressure components, tanks and piping, and the membrane filter. O&M costs include system and effluent monitoring, and sludge handling.
Ion Exchange	Ion exchange can treat extracted groundwater at OU 2. Ion exchange involves the transfer of one ion from an insoluble exchange material for a different ion in solution.	Ion exchange is implementable at OU 2 Chemicals used for regeneration may be expensive and the waste regenerant must be disposed of, increasing the cost. The expensive ion-exchange resins can be ruined if the system is not operated properly. This technology may require pretreatment prior to its use as a primary treatment.	Ion exchange is designed to treat inorganic compounds. An advantage of ion exchange is it can often remove unwanted ions preferentially including iron, manganese, and heavy metals. It does not remove volatile and semivolatile organic compounds or fuel hydrocarbons effectively.	Chemicals used for treatment can significantly increase O&M costs. In addition, post-treatment process waste water handling will increase O&M. Principle capital costs include piping and tank installation and the ion exchange resin.

Note:
{1} = GWRTAC (October, 1996) *Technology Overview Report· Phytoremediation*

— Initial capital costs are significantly higher than those of competing technologies; however, no operations and maintenance costs are associated with this technology.

- **Electrokinetic Remediation** was screened from further consideration because the contamination is already consolidated in isolated aquifer areas. In general, electrokinetic remediation is used to consolidate groundwater contamination to increase the extraction technology's effectiveness. Furthermore, this alternative is typically more effective when the CEC and salinity are low. Because the contamination in Sites 11, 12, and 26 are adjacent to a saltwater source (Yacht Basin), its salinity would likely interfere with the remedial processes. Furthermore, sodium concentrations in the groundwater consistently exceed freshwater criteria across the site.

- **Enhanced Biodegradation** was screened from further consideration for the following reasons:

  — Biodegradation may be limited by the potential for background inorganics to cause microbial fouling due to the addition of oxidizing agents and pH fluctuations. Furthermore, high inorganic concentrations may be toxic to the microbial population.

  — Low contaminant concentrations will not provide a suitable substrate mass to support sustained biomass growth.

  — The wide range of contaminants in the aquifer may decrease the effectiveness of enhanced bioremediation.

- **Passive Reactive Barrier** was screened from further consideration because site geology may limit its effectiveness (low-permeability zone may be too deep for conventional trenching methods). In addition, the contaminated groundwater does not appear to be migrating in Sites 11, 12, and 26. This conclusion is based on site hydrogeology and analytical results (nondetects) from downgradient surface water and sediment samples.

- **Bioreactors** were screened from further consideration because low organic contaminant concentration in OU 2 groundwater would not be sufficient to support microbial growth. Other treatment options are more effective.

- **Carbon Adsorption** was screened from further consideration because of the potential for carbon to be inorganically fouled. Furthermore, the high cost of O&M may be prohibitive for remediation at this site

Technologies retained for further consideration are listed below

- **Containment:** Groundwater extraction.

- **In situ management:** Phytoremediation and monitored natural attenuation.

- **Ex situ treatment:** Groundwater extraction and air stripping with inorganics pretreatment (coagulation/precipitation, filtration, or ion exchange).

- **Offsite disposal:** Disposal to the FOTW.

The NCP requires evaluation of a no-action alternative as a basis of comparison with other remedial alternatives. Because no action may result in contaminants remaining onsite, CERCLA, as amended, requires a review and evaluation of site conditions every five years. The no-action alternative will be carried through and analyzed throughout the FS process.

8.5 Development and Preliminary Evaluation of Remedial Alternatives

Following identification and screening of technologies, general response actions and process options are combined to form alternatives that address the entire site. These process options were chosen as representatives of technology types. In assembling alternatives, the NCP goal of evaluating a range of alternatives was considered. In keeping with this goal, the alternatives vary in level of effort, balance of containment versus treatment measures, cost, and remediation time frame The following alternatives have been developed

- **Alternative G1:** No-action
- **Alternative G2:** Monitored natural attenuation
- **Alternative G3:** Phytoremediation
- **Alternative G4:** Groundwater extraction and dispo al to the FOTW
- **Alternative G5:** Groundwater extraction and air stripping with inorganics pretreatment
  - *Pretreatment A:* Coagulation/precipitation
  - *Pretreatment B:* Membrane filtration
  - *Pretreatment C:* Ion exchange

8.5.1 Alternative G1: No Action

The NCP requires that a no-action alternative be considered as a "baseline" against which all other alternatives will be evaluated. In the no-action alternative, no remedial action will be taken. Future site use will be uncontrolled, and groundwater may be used for residential purposes.

Because wastes would remain at OU 2, SARA requires that the data collected from the site be evaluated every five years. This evaluation would include spatial and temporal analysis of existing data to determine increasing, decreasing, or stationary trends in contaminant concentrations. The results of this evaluation would be used to maintain, increase, or decrease the number and types of samples and analysis required for the monitoring program. In addition, the need for remedial action would be re-evaluated every five years.

Implementability

This alternative is technically and administratively feasible. No construction, operation, or maintenance is required for no action. No technology-specific regulations are associated with this alternative.

Effectiveness

The no-action alternative does not reduce waste's toxicity, mobility, or volume in groundwater. However, it is expected that current conditions represent worst-case conditions and contaminant concentrations are attenuating, thus rendering groundwater less threatening with time.

Cost

NCP-required five-year monitoring costs are associated with this alternative. Costs associated with the no-action alternative are presented in Table 8-10.

Table 8-10
Alternative G1: No Action Cost

Action	Quantity	Cost	Total Cost
Groundwater sampling (field work)	110 hrs.	$130/hr.	$14,300
Groundwater analysis	26 samples every 5 years 5 QA/QC samples per sampling event	$610/sample	$18,900[a]
Reporting/engineering	LS	20% cost	$6,600
Miscellaneous, equipment, travel, supplies, etc.	LS	25% cost	$8,300
Subtotal			**$48,100**
Present value subtotal at 6% discount over 30 years			**$117,500**
Total Cost			**$117,500[b]**

Notes:
(a) = Groundwater analytical samples include total metals, VOCs, and SVOCs.
(b) = Cost based on sampling event once every five years.
LS = Lump Sum

8.5.2 Alternative G2: Monitored Natural Attenuation

Monitored natural attenuation is accepted as a remedial alternative for organic compounds dissolved in groundwater. The processes of biological degradation, advection, adsorption, dispersion, and volatilization can effectively reduce contaminant toxicity, mobility, or volume to levels that protect human heath and the environment. Monitored natural attenuation is typically used in conjunction with contaminant soil or source control actions as a groundwater remedial tool Institutional controls would be required.

RG exceedances are monitored when they are isolated and the contaminant mass associated with the exceedance is minimal Monitoring periodically measures contaminant concentrations and provides data that can be used to determine contaminant mobility, degradation, and dispersion rates

Monitored natural attenuation is used when:

- Active remediation is not practicable, cost effective, or when groundwater is unlikely to be used in the foreseeable future.

- Monitored natural attenuation is expected to reduce contaminant concentrations in the groundwater to RGs in a reasonable time

- There is little likelihood of exposure to contaminants because of site conditions.

- Natural biodegradable daughter products of the original COCs do not accumulate.

OU 2 conditions indicate that monitored natural attenuation is applicable based on an initial evaluation (e.g., presence of daughter products and a trend of declining contaminant mass in the direction of groundwater flow). Groundwater use restrictions would be required; consumption of any groundwater could be prevented through appropriate application of groundwater-use restrictions. Institutional and management action could limit excess risk to current and future workers. Groundwater at OU 2 is not a practical potable water source due to ambient concentrations of iron, manganese, and other inorganics. Monitored natural attenuation requires in-depth modeling and evaluation of contaminant degradation rates and fate and transport. In addition, sampling and analysis must be conducted throughout the process to confirm that degradation is proceeding at rates consistent with cleanup objectives.

Before monitored natural attenuation can be implemented as a long-term remedy, additional site characterization is required to assess its potential for success at the site First data should be collected to determine whether contaminants are biodegrading Biodegradation must be demonstrated at rates sufficient to prevent dissolved contaminants from completing exposure pathways or reaching a predetermined point of compliance at concentrations exceeding applicable regulatory standards or RGs The monitored natural attenuation evaluation includes the following:

- Determining groundwater flow and solute-transport parameters.
- Addressing any sources and current and future exposure points.
- Comparing transport rates to attenuation rates.

If the initial screening process supports monitored natural attenuation, the site characterization must be used to build the quantitative model of solute fate and transport. Additional data may be required for the model. RI data may be used in the screening process, if applicable. The model is then used with a long-term groundwater monitoring plan to document and confirm monitored natural attenuation progress.

A long-term groundwater monitoring plan is used to assess plume migration over time and to verify that monitored natural attenuation is occurring at rates sufficient to protect potential downgradient receptors. Long-term sampling frequency depends on groundwater flow velocity, the location of the point-of-compliance monitoring well(s), and other regulatory issues considered during risk management decision making. If monitored natural attenuation does not meet remedial requirements during long-term monitoring, other remedial technologies may be implemented to assist or replace it.

Implementability

This alternative is technically feasible It must be screened during remedial design (RD) to determine if monitored natural attenuation can effectively reduce contaminants to concentrations that protect human heath and the environment No construction, operation, or maintenance would be initially required The plume and PRG exceedances can be monitored using existing monitoring wells However, additional monitoring wells might need to be constructed and maintained during long-term monitoring No technology-specific regulations would apply

This alternative is administratively feasible. OU 2 can be designated an industrial area and the use of the groundwater beneath the site can be restricted with institutional controls. If monitored natural attenuation can be shown to reduce contaminants in a reasonable time, regulatory concurrence is possible. Community acceptance would need to be obtained and would require educating the general public on the difference between no action and monitored natural attenuation.

Effectiveness

Protection of human health and the environment is accomplished by institutionally controlling exposure to site groundwater and its use. This alternative requires current use of the site as an industrial area to continue for the foreseeable future; land and groundwater-use restrictions can be implemented. Should use of OU 2 change, the site might need to be re-evaluated.

Long-term effectiveness would be accomplished through the reduction of contaminant toxicity, mobility, and volume through the processes of biodegradation, advection, adsorption, dispersion, and volatilization.

Restoration of site groundwater to RGs, which might be accomplished upon completion of the monitored natural attenuation program, would reduce groundwater to below RGs for nonambient compounds This alternative may reduce contamination below RGs but the amount of time required for complete attenuation is not known As discussed in the remedial elements section of this alternative, remedial design must first assess biodegradation kinetics. The presence of VOC breakdown products at OU 2 is not the only evidence that biodegradation is occurring at rates that can reach remedial goals: other evidence includes (1) historical groundwater or soil chemistry data that demonstrates a clear and meaningful trend of declining contaminant mass and/or concentrations at appropriate monitoring or sampling points, (2) hydrogeologic or geochemical data that can be used to indirectly demonstrate the type(s) of active natural attenuation processes at the site, and (3) data from field or microcosm studies which directly demonstrate the occurrence of a particular natural attenuation process at the site and the ability to degrade the contaminants of concern. If biodegradation is demonstrated to be effective, a full monitored natural attenuation site screening and fate-and-transport modeling would need to be performed. Screening would determine if monitored natural attenuation applies to OU 2. In-depth, long-term monitoring would be used to demonstrate monitored natural attenuation effectiveness.

Monitoring of RG exceedances does not effectively reduce contaminant concentrations in groundwater. However, monitoring does provide data that can be used to measure contaminant mobility, degradation, dispersion, i.e., verify the effectiveness of natural attenuation.

Cost

Cost components for the monitored natural attenuation alternative would include the following (shown in Table 8-11):

- Initial monitored natural attenuation assessment
- Fate-and-transport modeling
- Groundwater sampling and analysis
- Engineering, institutional controls, and report preparation

Table 8-11
Alternative G2 : Monitored Natural Attenuation Costs

Action	Quantity	Cost	Total Cost
Initial screening			
Groundwater sampling (field work)	110 hrs.	$130/hr	$14,300
Groundwater analysis	26 samples 5 QA/QC	$610/sample	$18,900*
Evaluation (includes fate-and-transport modeling)	260 hrs.	$94/hr	$24,400
Reporting/engineering	LS	20% cost	$11,500
Misc: equipment, travel, supplies, software, etc.	LS	25% cost	$14,400
Subtotal			**$83,500**
Monitored natural attenuation initial startup program			
Groundwater sampling (field work)	400 hrs.	$130/hr	$52,000
Groundwater analysis	26 samples per month (3-month period) 5 QA/QC per sampling event	$610/sample	$56,700*
Institutional controls	LS	$50,000	$50,000
Reporting/engineering	LS	20% cost	$31,700
Misc: equipment, travel, supplies	LS	25% cost	$39,700
Subtotal			**$230,100**
Total capital costs			**$313,600**

Table 8-11
Alternative G2 : Monitored Natural Attenuation Costs

Action	Quantity	Cost	Total Cost
Monitored natural attenuation long-term monitoring annual program			
Groundwater sampling (field work)	110 hrs.	$130/hr.	$14,300
Groundwater analysis	26 samples per year 5 QA/QC per sampling event	$610/sample	$18,900
Evaluation	130 hrs.	$94/hr	$12,200
Reporting/engineering	LS	20% cost	$9,100
Misc. equipment, supplies, travel	LS	25% cost	$11,400
Subtotal			**$65,900**
Present value subtotal at 6% for 30 years			**$907,100**
Remedial action contractor (RAC)			**$100,000**
Total			**$1,320,700**

Notes:
(*) = Groundwater analytical samples include total metals, VOCs, and SVOCs.
LS = Lump Sum

8.5.3 Alternative G3: Phytoremediation

Phytoremediation is an emerging technology that uses specific plant species and their associated rhizospheric microorganisms to remove, degrade, or contain chemical contaminants in soil, sediments, groundwater, surface water, and even the atmosphere. Several types of phytoremediation systems would be applicable to Sites 11, 12, and 26:

- *Rhizofiltration:* Water remediation technique involving the uptake of contaminants by plant roots. Hyperaccumulation is related to this process. Hyperaccumulation, a specific technology for the remediation of low-level, widespread heavy-metal and radionuclide contamination, is defined as the ability of a plant to uptake and store more than 2.5% of its dry weight in heavy metals. To accomplish hyperaccumulation, plants are grown in contaminated soil or water and assimilate the contaminants through a process known as translocation. In this process contaminants are absorbed by the root system of a plant and moved to the above ground parts of the plants/the stems and leaves/where they can easily be harvested and removed from the site.

- *Phytostabilization:* Use of certain plant species to absorb and precipitate contaminants, generally metals, reducing their bioavailability, and so reducing the potential for human exposure to these contaminants. Plants used in this process often produce a large root biomass that is able to immobilize the COCs through uptake, precipitation, or reduction.

- *Phytotransformation.* Use of certain plants to degrade contaminants through plant metabolism

- *Phytostimulation:* Stimulation of microbial biodegradation in the root zone. The plants provide carbonaceous material and essential nutrients through liquids released from roots and root tissue decay In addition oxygen released from plants increases the oxygen content in the microbially-rich rhizopheric zone

- *Phytovolatilization:* Plants are used to evapotranspirate metals and volatile organics.

In addition, groundwater migration can be affected through the use of deep-rooted trees such as poplars to capture groundwater and retard contaminant migration. The trees take up the water and then transpire it, potentially depressing the local water table. If enough trees use the groundwater in a limited area, the water table may be depressed up to the equivalent of 3 feet of rainfall per year in semiarid areas. Contaminated groundwater that would have migrated down gradient is contained in the poplar's root zone, where degradation can occur through plant processes and plant-assisted bioremediation.

Laboratory and field studies would be used to determine the appropriate species of plant required to remediate the COCs. In addition, these studies would help in the planting scheme design including plant spacing, fertilization frequency, soil amendments, and water requirements.

Implementability

Phytoremediation is technically and administratively feasible at Sites 11, 12, and 26. Areas to be remediated are readily accessible. The groundwater contaminants are very shallow (<3 feet bgs) which contributes to phytoremedial success using poplars or other long-rooted trees. Poplar trees have been demonstrated to extract groundwater from water tables as deep as 10 feet. Because there are at least eight species of Poplar indigenous to North America and their ability to form hybrids, it is expected that Poplars can be cultivated in Pensacola (Chappell, 1997).

Overall, this alternative is easy to install, maintain, and monitor. Only landscaping equipment will be required to implement this technology Confirmatory sampling would be required to monitor the performance of the process No future remedial actions would be required after this alternative is completed.

Specific methods for application to contaminated sites have not been standardized, but general principles have been established. The general steps followed in the design and implementation of a phytoremediation project for any of the techniques include:

- Site characterization, including determination of soil and water chemistry/conditions, climate, and contaminant distributions.

- Treatability studies to determine rates of remediation and appropriate plant species, density of planting, location, etc. Agricultural analyses and principles are required to complete the treatability study.

- Preliminary field testing at the site to monitor results and refine design parameters.

- Full-scale remediation

- Disposition of resulting plant material.

Effectiveness

Use of phytoremediation is currently limited to research activities and limited field testing. While several recent and on-going applications have reportedly been successful in lowering contaminant concentrations, complete full-scale applications of this innovative technology projects are scarce Reported results show fair potential for practical applications of these techniques to achieve remedial objectives and regulatory approval; however, at least two or three more years of field tests are necessary to validate the initial, small scale field tests.

Sites 11 12, and 26 are sufficiently removed from the public to reduce health and safety concerns associated with groundwater remediation Workers would be exposed to increased particulate emissions during grading and planting activities and might also have dermal contact with potentially hazardous soil constituents. However, worker risks can be reduced by implementing dust control technologies and a site-specific health and safety plan specifying PPE, respiratory protection, etc.

Phytoremediation would probably take years to satisfy remedial objectives. Table 8-12 summarizes its advantages and limitations.

Table 8-12
Phytoremediation Advantages and Limitations
(Miller, 1996 and Chappell, 1997)

Advantages	Limitations
In situ technology	Limited to shallow soils, streams, and groundwater — generally restricted to groundwater within 10 feet of the ground surface
Passive treatment with minimal associated O&M	High concentration of hazardous materials can be toxic to plants
Solar powered	Regulator unfamiliarity
Organic pollutants may be degraded to carbon dioxide and water, removing, as opposed to transferring, environmental toxicity	Climatic and agricultural conditions may influence growth rate and indirectly, treatment system effectiveness
Cost-effective for large volumes of water having low concentrations	Slower than mechanical-treatment systems
Overall costs can be 10% to 20% of traditional ex situ systems.	Only effective for moderately hydrophobic contaminants
Transfer is faster than monitored natural attenuation	Toxicity and bioavailability of degradation products are unknown
Significant public acceptance	Contaminants may be mobilized into the groundwater (for soil applications)
Air and water emissions are minimal	Contaminants may enter food chain through animal consumption
Secondary wastes are not generated	
Soil and groundwater remain in place and can be used post-treatment	

Cost

Costs associated with phytoremediation are presented in Table 8-13; however, current estimates costs for phytoremediation vary widely.

Table 8-13
Alternative G3: Phytoremediation Costs

Action	Quantity	Cost	Total Cost
Capital Costs			
Laboratory/pilot/field studies	LS	$80,000	$80,000
Mobilization/demobilization	LS	$5,000	$5,000
Planting	3 acres	$10,000/acre	$30,000
Soil cover and amendments	3 acres	$7,500	$22,500
Institutional controls	LS	$30,000	$30,000
Engineering/oversight	LS	20%	$33,500
Contingency/miscellaneous	LS	25%	$41,900
Subtotal			**$242,900**
Operations and Maintenance Costs			
Horticulture (plant health)	3 acres	$1,000/acre	$3,000
Pruning	3 acres	$1,000/acre	$3,000
Harvesting	3 acres	$2,000/acre	$6,000
Inspection	LS	$1,000	$1,000
Subtotal			**$13,000**
Present Value at 6% discount rate over 30 years			**$178,900**
Phytoremediation Long-term Monitoring Annual Program			
Groundwater sampling (field work)	110 hrs	$130/hr	$14,300
Groundwater analysis	26 samples per year 5 QA/QC per sampling event	$610/sample	$18,900*
Evaluation	130 hrs	$94/hr	$12,200
Reporting/engineering	LS	20% cost	$9,100
Misc. equipment, supplies, travel	LS	25% cost	$11,400
Subtotal			**$65,900**
Present value subtotal at 6% for 30 years			**$907,100**
RAC			**$100,000**
Total			**$1,428,900**

Notes:
Cost estimates developed from Miller, 1996 and Chappell, 1997.
* = Groundwater analytical samples include total metals, VOCs, and SVOCs.
LS = Lump Sum

8.5.4 Alternative G4: Groundwater Extraction and Disposal to the FOTW

The overall objective of the groundwater recovery system is containment of groundwater in which contaminants exceed PQG criteria and mass removal from the aquifer. The objective of monitoring exceedances is to determine fluctuations in contaminant concentrations over time to ascertain contaminant degradation, mobility, and dispersion rates.

Groundwater recovery is possible using various well collection configurations. However, since the contamination is restricted to two isolated locations, only one groundwater collection scenario will be evaluated: one extraction well adjacent to well 11GM47 and one extraction well adjacent to wells 11GS13, 11GM52, and 11GI14 (shown on Figure 8-9). Extracted groundwater will be discharged to the FOTW through the sanitary sewer system

Lead contamination at well 11GM15 will be monitored with routine sampling Due to slightly acidic pH conditions (average pH ~6 3) it is assumed that a significant fraction of the lead is undissolved and thus in the form of immobilized precipitates If lead contamination persists beyond well 11GM15 (i.e , detected in downgradient wells), remedial actions will be undertaken — an extraction well will be placed near the well to remove the contamination.

Implementability

OU 2 conditions are amenable to a groundwater recovery system for capture of the contaminated groundwater plume. Groundwater extraction as a remedial alternative is viable technically. Operations would be expected to be reliable and require little maintenance. Groundwater recovery is administratively feasible, as it is commonly employed as a remedial alternative. Extraction rates should be minimized to reduce the chance of saline intrusion.

Discharge to the FOTW can be technically implemented. A delivery and piping connection to the sanitary sewer can be constructed to discharge extracted groundwater. The FOTW can handle the

FIGURE 8-9
EXTRACTION WELL LOCATIONS
SITES 11,12, AND 26

DWG DATE:04/19/99 | DWG NAME:0970B020

maximum projected flow rates. Effluent concentrations of the treatment system would be required to meet the FOTW discharge criteria

This alternative does not include the use of pretreatment or blending, but pretreatment would be needed if the FOTW were unable to receive the current contaminant concentrations in the groundwater. Communication with the NAS Pensacola staff to determine pretreatment requirements would be necessary to complete the evaluation of this alternative's implementability. The remaining discussion of this alternative is based on the assumption that pretreatment would not be required Alternative G5 addresses treatment if required.

Effectiveness

Groundwater extraction and discharge offers additional protection for current and future site workers when combined with the use of institutional controls and routine monitoring and sampling Contaminated groundwater would be effectively contained and removed This alternative would reduce the toxicity and mobility of the contaminated groundwater by extracting it from the aquifer. However, contaminants would be treated at the FOTW Currently, it is difficult to estimate the volume of water that would need to be extracted and removed to achieve adequate contaminant containment.

Cost

The costs are based on two extraction wells with a combined flow rate of 15 gpm and includes capital, annual operation and maintenance, and discharge costs. Cost analysis is based on preliminary data and modeling for feasibility purposes and cannot be considered a final design. Costs are summarized in Table 8-14. This alternative is expected to take three years to complete; cost calculations reflect this estimate.

Table 8-14
Alternative G4: Groundwater Recovery and Discharge Costs

Action	Quantity	Cost	Total Cost
Capital Costs			
Aquifer test	1	$30,000 / each	$30,000
Extraction well construction	2	$5,000 / well	$10,000
Pumps and switches	2	$3,000 / pump	$6,000
Piping and connections/excavation and backfill	LS	$20,000	$20,000
Institutional controls	LS	$50,000	$50,000
Engineering support/report preparation	LS	20% cost	$23,200
Misc. Supplies, equipment, travel	LS	25% cost	$29,000
FOTW costs	24 million gallons (5 times affected volume)	$3.00 / 1000 gal.	$72,000
Subtotal			**$240,200**
Annual operation and maintenance costs			
Maintenance	12 months	$1,000 / month	$12,000
Electricity	10,000 kwhr	$.07 / kwhr	$700
Replacement pumps	3	$500 / pump	$1,500
Permitting/engineering support	LS	20% cost	$2,800
Misc. equipment, supplies, travel, etc.	LS	25% cost	$3,500
Subtotal			**$20,500**
Present value cost at 6% discount over 3 years			**$54,800**
Monitoring			
Sampling Labor	100 hours	$ 130.00 / hr	$13,000
Laboratory	25 samples	$610.00 / sample	$15,300*
Evaluation	40 hours	$94.00 / hr	$3,800
Engineering support / report preparation	LS	20%	$6,400
Misc. equipment, supplies, travel, etc.	LS	25%	$8,000
Subtotal			**$46,500**
Present value cost at 6% discount over 3 years			**$124,300**
RAC			**$100,000**
Groundwater Recovery and Discharge Total			**$519,300**

Notes:

* = Groundwater analytical samples include total metals, VOCs, and SVOCs.
LS = Lump Sum
kwhr = kilowatt hour
gal = gallons

8.5.5 Alternative G5: Groundwater Extraction and Air Stripping with Inorganics Pretreatment

Under this alternative, groundwater would be extracted using the same methodology and rationale as Alternative G4. However, the extracted groundwater would be treated at a centralized location using coagulation/precipitation, membrane filtration, or ion exchange to remove inorganic contaminants and then air stripping to remove volatile organics rather than discharging directly to the FOTW. The inorganics must be treated first to avoid equipment fouling and process complications. Following air stripping, the treated groundwater would be discharged to the FOTW through the sanitary sewer system. The FOTW can handle the maximum projected flow rates Effluent concentrations of the treatment system would be required to meet FOTW discharge criteria

- *Pretreatment A Coagulation/Precipitation* Removal of primary and secondary heavy metals arsenic, cadmium, chromium, lead, iron, aluminum, and manganese — might be required The treatment technology most frequently used is coagulation precipitation, and filtration. Such technologies are proven, effective, and implementable at OU 2. The sludge generated by this treatment technology would require dewatering (such as by filter press) to increase solid contents before disposal.

- *Pretreatment B: Membrane Filtration:* Membrane filtration uses selective semipermeable materials to remove dissolved solids, such as metal salts, from the extracted groundwater. Water recovery is determined by temperature, operating pressure, and membrane surface area This technology is proven, effective, and implementable at OU 2. The sludge generated by this treatment technology would require dewatering (such as by filter press) to increase solid contents before disposal

- *Pretreatment C: Ion Exchange:* Ion exchange effectively treats dilute aqueous waste streams containing inorganic compounds. This technology efficiently removes iron, manganese, and many heavy metals. The groundwater is pumped through a tank containing an exchange resin. Once all the readily exchangeable ions on the exchange resin have been replaced by dissolved ions, the exhausted resin is regenerated with a solution which provides a concentrated supply of the originally bound ions. Performance is influenced by the nature of the functional group, ions available for exchange, and solution pH.

- *Primary Treatment: Air Stripping:* Air stripping is an established technology, and is effective for groundwater remediation Volatile organics are partitioned from groundwater by increasing the surface area of the contaminated water exposed to air. Types of aeration methods include packed towers, diffused aeration tray aeration, and spray aeration. Tray aeration has been preliminarily selected for OU 2 Off-gas treatment might be required for VOCs generated at the air stripper but preliminary calculations show mass transfer rates are less than allowed by Florida Air Pollution Rules 62 210 and 62-296 for Escambia County. Treated groundwater could be disposed of offsite through the FOTW or Pensacola Bay

Implementability

OU 2 conditions are amenable to a groundwater recovery system to capture the contaminated groundwater plume. Groundwater extraction as a remedial alternative is viable technically Operations would be expected to be reliable and require little maintenance. Groundwater recovery is administratively feasible, as it is commonly employed as a remedial alternative. Extraction rates should be minimized to reduce the chance of saline intrusion.

Groundwater treatment processes selected for this alternative are both technically and administratively feasible at OU 2 The implementation of both the air stripping for VOCs and physical-chemical treatment system for inorganics at the site is technically feasible. Specific groundwater characteristics to be determined before design and implementation are flow rate, influent concentrations, and effluent criteria.

A monitoring system should be instituted to measure process operating efficiencies of the treatment system. Various designs of physical-chemical, air stripping, and offgas treatment equipment are readily available from vendors. Offgas treatment units are available on a loan or purchase basis.

The groundwater pump-and-treat system is administratively feasible. Pump-and-treat systems have historically been used to remediate contaminated aquifers. Administrative requirements would include obtaining offsite transportation permits for treatment and/or disposal of the solids generated by the treatment process Any sludge generated from the treatment process would be disposed of at an offsite landfill Solids exhibiting the toxicity characteristic would have to be disposed of offsite as a hazardous waste Air pollution standards would be met using offgas controls (such as carbon adsorption) before release of the air-stream to the environment

Discharge to the FOTW is technically and administratively implementable. A delivery and piping connection to the sanitary sewer can be constructed to discharge extracted groundwater. Sampling treated groundwater effluent might be necessary to meet FOTW discharge requirements. If discharge to the FOTW is not possible, pretreatment, and NPDES discharge options might be considered.

Effectiveness

The groundwater extraction, treatment, and discharge alternative offers additional protection for current and future site workers when combined with institutional controls and sampling and monitoring Contaminated groundwater would be effectively contained and removed. This alternative would reduce the toxicity and mobility of the contaminated groundwater by eliminating it from the aquifer. Furthermore, the waste volume would be reduced using air stripping and its associated physical/chemical treatment system. Organic constituents would be transferred to the atmosphere (if the concentrations meet air regulations) or consolidated on another media (e.g. activated carbon). The inorganic compounds would be consolidated as a sludge (precipitation/coagulation and membrane filtration) or a highly concentrated liquid waste (ion exchange). Currently, it is difficult to estimate the volume of water that would need to be treated and the time required for aquifer restoration due to contaminant retardation in the aquifer.

Air stripping combined with precipitation/coagulation, membrane filtration, or ion exchange are highly effective for contaminant treatment at OU 2 The treatment process would effectively remove contaminants to concentrations below discharge limits.

Monitoring of exceedances does not effectively reduce contaminant concentrations in groundwater However, monitoring does assess remedy performance

Cost

Cost associated with this alternative are based groundwate extraction and discharge and one of the following:

- Groundwater treatment:
- G5a: Coagulation/Precipitation and Air Stripping
- G5b: Membrane Filtration and Air Stripping
- G5c: Ion Exchange and Air Stripping

The costs, which are based on two extraction wells with a combined flow rate of 15 gpm, includes capital, annual operation and maintenance, and treatment. Cost analysis is based on preliminary data and modeling for feasibility purposes, and not a final design. Costs are summarized in Tables 8-15, 8-16 a, b, and c, and 8-17.

Table 8-15
Alternative G5: Groundwater Recovery and Discharge Costs

Action	Quantity	Cost	Total Cost
Capital Costs			
Aquifer test	1	$30,000 / each	$30,000
Extraction well construction	2	$5,000 / well	$10,000
Pumps and switches	2	$3,000 / pump	$6,000
Piping and connections/excavation and backfill	LS	$20,000	$20,000
Institutional controls	LS	$50,000	$50,000
Engineering support/report preparation	LS	20% cost	$23,200
Misc. supplies, equipment, travel	LS	25% cost	$29,000
FOTW costs	24 million gallons (5 times affected volume)	$3.00 / 1000 gal.	$72,000
Subtotal			**$240,200**
Annual Operation and Maintenance Costs			
Maintenance	12 months	$1,000 / month	$12,000
Electricity	10,000 kwhr	$.07 / kwhr	$700
Replacement pumps	3	$500 / pump	$1,500
Permitting/engineering support	LS	20% cost	$2,800
Misc. equipment, supplies, travel, etc.	LS	25% cost	$3,500
Subtotal			**$20,500**
Present value cost at 6% discount over 3 years			**$54,800**
Monitoring			
Sampling Labor	100 hours	$130.00 / hr	$13,000
Laboratory	25 samples	$610.00 / sample	$15,300*
Evaluation	40 hours	$94.00 / hr	$3,800
Engineering support / report preparation	LS	20%	$6,400
Misc. equipment, supplies, travel, etc.	LS	25%	$8,000
Subtotal			**$46,500**

Table 8-15
Alternative G5: Groundwater Recovery and Discharge Costs

Action	Quantity	Cost	Total Cost
Present value cost at 6% discount over 3 years			**$124,300**
RAC			**$100,00**
Groundwater Recovery and Discharge Total			**$519,300**

Notes:
* = Groundwater analytical samples include total metals, VOCs, and SVOCs.
LS = Lump Sum
gal = gallons
kwhr = kilowatt hour

Table 8-16a
Alternative G5a: Precipitation/Coagulation and
Air Stripping System Treatment Costs

Action	Quantity	Cost	Total Cost
Capital Costs			
Pretreatment system			
Building	LS	$262,200	$262,200
Air supply system	1	$29,900 / each	$29,900
Tanks	1	$45,500 / each	$45,500
Pumps and accessories	LS	$81,300	$81,300
Treatment system	LS	$168,400	$168,400
Process controls	LS	$67,600	$67,600
Installation	LS	$132,000	$132,000
Engineering	LS	20%	$157,400
Contingency	LS	25%	$196,800
Subtotal			**$1,141,100**
Air stripping treatment costs			
Treatment System	LS	$46,800 / each	$46,800
Tanks	LS	$15,600 / each	$15,600
Pumps and accessories	LS	$41,900 / each	$41,900
Process controls	LS	$19,500 / each	$19,500
Installation	LS	$46,800 / each	$46,800

Table 8-16a
Alternative G5a: Precipitation/Coagulation and Air Stripping System Treatment Costs

Action	Quantity	Cost	Total Cost
Engineering	LS	20%	$34,100
Contingency	LS	25%	$42,700
Subtotal			**$247,400**
Total capital costs			**$1,368,500**
Annual Operating Costs			
Physical/chemical process	LS	$100,000	$100,000
Air stripping process	LS	$78,000	$78,000
Subtotal			**$178,000**
Present value cost at 6% discount over 3 years			**$475,800**
Solid Waste Disposal Annual Costs			
Transportation	100 cy	$10 / cy	$1,000
Sludge disposal	100 cy	$225 / cy	$22,500
Engineering / oversight	LS	20%	$4,700
Contingency	LS	25%	$5,900
Subtotal			**$34,100**
Present value cost at 6% discount over 3 years			**$91,100**
Treatment system total			**$1,955,400**
Treatment system total with groundwater recovery and discharge			**$2,474,700**

Notes:
LS = Lump Sum
cy = cubic yard

Table 8-16b
Alternative G5b: Membrane Filtration and
Air Stripping System Treatment Costs

Action	Quantity	Cost	Total Cost
Capital Costs			
Pretreatment system			
Building	LS	$200,000	$200,000
Tanks	3	$7,500 / each	$22,500
Pumps and accessories	LS	$25,000	$25,000
Treatment system	LS	$40,000	$40,000
Process controls	LS	$25,000	$25,000
Installation	LS	$20,000	$20,000
Engineering	LS	20%	$66,500
Contingency	LS	25%	$83,100
Subtotal			**$482,100**
Air stripping treatment costs			
Treatment system	LS	$46,800 / each	$46,800
Tanks	LS	$15,600 / each	$15,600
Pumps and accessories	LS	$41,900 / each	$41,900
Process controls	LS	$19,500 / each	$19,500
Installation	LS	$46,800 / each	$46,800
Engineering	LS	20%	$34,100
Contingency	LS	25%	$42,700
Subtotal			**$247,400**
Total capital costs			**$729,500**
Annual Operating Costs			
Physical/chemical process	LS	$70,000	$80,000
Air stripping process	LS	$78,000	$78,000
Subtotal			**$158,000**
Present value cost at 6% discount over 3 years			**$422,300**

Table 8-16b
Alternative G5b: Membrane Filtration and Air Stripping System Treatment Costs

Action	Quantity	Cost	Total Cost
Solid Waste Disposal Annual Costs			
Transportation	100 cy	$10 / cy	$1,000
Sludge disposal	100 cy	$225 / cy	$22,500
Engineering / oversight	LS	20%	$4,700
Contingency	LS	25%	$5,900
Sub-total			**$34,100**
Present value cost at 6% discount over 3 years			**$91,100**
Treatment system total			**$1,242,900**
Treatment system total with groundwater recovery and discharge			**$1,762,200**

Notes:
LS = Lump Sum
cy = cubic yard

Table 8-16c
Alternative G5c: Ion Exchange and Air Stripping System Treatment Costs

Action	Quantity	Cost	Total Cost
Capital Costs			
Pretreatment system			
Building	LS	$200,000	$200,000
Tanks	3	$7,500 / each	$22,500
Pumps and accessories	LS	$25,000	$25,000
Treatment system	LS	$60,000	$60,000
Process controls	LS	$25,000	$25,000
Installation	LS	$60,000	$60,000
Engineering	LS	20%	$78,500
Contingency	LS	25%	$98,100
Subtotal			**$569,100**

Table 8-16c
Alternative G5c: Ion Exchange and Air Stripping System Treatment Costs

Action	Quantity	Cost	Total Cost
Air stripping treatment costs			
Treatment system	LS	$46,800 / each	$46,800
Tanks	LS	$15,600 / each	$15,600
Pumps and accessories	LS	$41,900 / each	$41,900
Process controls	LS	$19,500 / each	$19,500
Installation	LS	$46,800 / each	$46,800
Engineering	LS	20%	$34,100
Contingency	LS	25%	$42,700
Subtotal			**$247,400**
Total capital costs			**$816,500**
Annual Operating Costs			
Physical/chemical process	LS	$150,000	$150,000
Air stripping process	LS	$78,000	$78,000
Subtotal			**$228,000**
Present value cost at 6% discount over 3 years			**$609,400**
Disposal of Liquid Waste at Treatment Facility Annual Costs			
Treated water disposal	50,000 gallons	$1.00 / gal.	$50,000
Engineering / oversight	LS	20%	$10,000
Contingency	LS	25%	$12,500
Subtotal			**$72,500**
Present value cost at 6% discount over 3 years			**$193,800**
Treatment system total			**$1,619,700**
System total with groundwater recovery and discharge			**$2,139,000**

Notes:
LS = Lump Sum
gal = gallons

Table 8-17
Alternative G5: Groundwater Extraction and Treatment Cost Summary

Treatment Method	Extraction and Discharge	Pretreatment System	Air Stripping Treatment	PW O&M Annual	PW Disposal	Total
Air Stripping with Coagulation/ Precipitation	$519,300	$1,141,100	$247,400	$475,800	$91,100	$2,474,700
Air Stripping with Membrane Filtration	$519,300	$482,100	$247,400	$422,300	$91,100	$1,762,200
Air Stripping with Ion Exchange	$519,300	$569,100	$247,400	$609,400	$193,800	$2,139,000

Notes:
PW = present worth
O&M = operations and maintenance

8.6 Detailed Development and Evaluation of Remedial Alternatives

The following sections analyze the groundwater alternatives presented in Section 8.5. Each alternative is evaluated according to the criteria discussed in Section 2.4. Criteria have been divided into three categories — threshold, balancing, and modifying.

8.6.1 Alternative G1: No-Action

The no-action alternative for OU 2 involves no active remedial effort. No actions would be taken to contain, remove, or treat groundwater contamination. Groundwater would remain in place to attenuate according to biotic, abiotic, dilution, dispersion and other natural processes. No engineering or institutional controls would be constructed. The no-action alternative provides a baseline against which other alternatives are compared.

Threshold Criteria

The alternatives must meet two threshold criteria to be considered in the FS: overall protection of human health and the environment and compliance with ARARs.

Overall Protection of Human Health and the Environment

The no-action alternative provides no additional protection of human health and the environment. Groundwater concentrations at OU 2 exceed RGs Under the no-action scenario, these exceedances would remain; it is assumed that current groundwater contamination is "worst case" and attenuating. The surficial/sand-and-gravel aquifer is not a potable water source. As discussed previously, the main producing zone is the primary source of potable water.

The no-action alternative does not afford any long-term effectiveness and permanence under an industrial scenario beyond natural degradation of constituents. No short-term impacts are associated with this alternative which does not reduce the mobility or volume of contaminants at OU 2 but rather allows contaminant s natural attenuation to be monitored every five years. This alternative does not comply with chemical-specific ARARs and to-be-considered (TBC) criteria because groundwater exceeding RGs could theoretically be consumed under the uncontrolled use scenario However, groundwater consumption is not likely, as previously mentioned

Compliance with ARARs

Alternative G1 does not comply with the chemical-specific ARARs developed in Section 9.1. Groundwater in which contaminants exceed RGs would remain. Florida Proposed Rule 62-777 is a potential ARAR for OU 2. No location- or action-specific ARARs are triggered by the no-action alternative.

Balancing Criteria

The primary balancing criteria are the technical criteria on which the detailed analysis is based.

Long-term Effectiveness and Permanence

Degradation of site contaminants is left to natural attenuation processes in this alternative, and the long-term effectiveness of the no-action alternative is minimal. Current contaminant concentrations would attenuate slowly. Groundwater volume and concentrations would remain unchanged, except for intrinsic attenuation. The no-action alternative does not reduce the magnitude of residual risk and provides no means for monitoring. This alternative lacks treatment actions that would provide permanence.

Controls currently in place at the site — which include military security and limited site access and use — would remain. Due to the abundant supply of high quality water in the deeper main producing zone, groundwater from the surficial zone is not used as a potable water source in southern Escambia County, nor is it expected to be used for that purpose in the future.

Reduction of Toxicity, Mobility, or Volume Through Treatment

The no-action alternative would not reduce the mobility or volume of groundwater contaminants at OU 2 Toxicity may be reduced slowly through natural attenuation Contaminants would remain in place onsite: groundwater would not be treated during remedial actions However intrinsic remediation processes (either biotic or abiotic degradation) would continue and are considered irreversible Contaminated groundwater would migrate according to current transport dynamics.

Short-term Effectiveness

Short-term effectiveness assesses the effects of an alternative on human health and the environment while the remedial alternative is being implemented. No implementation concerns are associated with the no-action alternative. No risk is posed to the community, workers, or the environment during implementation. This alternative may be implemented immediately and continue indefinitely. There are no implementation risks associated with Alternative G1.

Implementability

The no-action alternative is technically feasible and easily implemented. No construction, operation, or reliability issues are associated with this alternative. Current access controls — including military security and limited access to personnel — have historically been reliable. No administrative coordination is required for implementation of the no-action alternative, which would not require offsite services, materials, specialists, or innovative technologies.

Cost

Costs associated with the no-action alternative include groundwater monitoring and report preparation every five years for 30 years Each sampling and reporting event is estimated at $48,100 with a present worth for the 30-year period of $117,500

Modifying Criteria

The modifying criteria are assessed formally after the public comment period However the criteria are factored into the identification of the preferred alternative as far as they are known

State/Support Agency Acceptance

FDEP and the USEPA are involved in the partnering team process and will both have the opportunity to review and comment on this proposed plan.

Community Acceptance

Community acceptance for the no-action alternative would be established after the FS public comment period.

8.6.2 Alternative G2: Monitored Natural Attenuation

Under this alternative, contaminated groundwater is left in place. The monitored natural attenuation alternative includes initial biodegradation assessment and fate-and-transport modeling to predict expected contaminant concentrations over time. Additional groundwater sampling would be required in support of this modeling. A long-term groundwater monitoring program would be implemented to assess the progress of monitored natural attenuation and to ensure that human health is protected. Institutional controls would be implemented with land-use restrictions that limit land to industrial use, and restrict groundwater use beneath and downgradient of the site.

Threshold Criteria

Overall Protection of Human Health and the Environment

Under an industrial scenario, monitored natural attenuation addresses the long-term effectiveness and permanence criterion by preventing exposure to the contaminant source. Protection of human health is accomplished by restrictions on groundwater use and attenuation of contaminant concentrations over time No short-term impacts would be associated with this alternative This alternative would not comply with chemical-specific ARARs This alternative would not be implemented if initial modeling and screening determined that RGs or protection of human health are not met

As previously discussed, no threats to Bayou Grande have been identified. Protection of the environment and Bayou Grande could be further monitored through monitored natural attenuation. Monitoring would help protect the Bayou Grande and the environment.

Compliance with ARARs

The monitored natural attenuation alternative is intended to comply with the chemical-specific groundwater ARARs. Modeling and groundwater sampling is intended to document degradation of contaminants over time. Florida Proposed Rule 62-777 is a potential ARAR for OU 2.

No location or action-specific ARARs would be triggered by groundwater Alternative G2.

Balancing Criteria

Long-term Effectiveness and Permanence

The monitored natural attenuation alternative eliminates residual risk to site workers by managing OU 2 as an industrial area and preventing groundwater from being used as a potable source through institutional controls. Groundwater modeling may show that monitored natural attenuation can reduce contaminants to RGs over time through natural biotic and abiotic attenuation processes. However, contaminant concentrations would likely attenuate slowly; therefore, long-term effectiveness would be minimal. The consumption of contaminated groundwater would be controlled institutionally and groundwater would be monitored until remedial goals are met

Any controls currently in place onsite including military security and limited access to the site — would remain. These controls are considered reliable for protecting human health, given the current and projected land use onsite

Reduction of Toxicity, Mobility, or Volume Through Treatment

Monitored natural attenuation does not reduce the mobility or volume through treatment. Toxicity is reduced slowly through monitored natural attenuation. However, toxicity may be increased due to incomplete degradation to more toxic products. Contaminants would remain in place onsite; groundwater is not treated during remedial actions. However, intrinsic remediation processes (either biotic or abiotic degradation) would continue and are considered irreversible. Contaminated groundwater would migrate according to current transport dynamics.

Short-term Effectiveness

No implementation concerns are associated with monitored natural attenuation. The community is protected through groundwater restrictions and institutional controls. Workers are protected by groundwater restrictions, equipment, and training. This alternative could be executed as soon as land-use restrictions and groundwater restrictions are in place. No implementation risks are associated with Alternative G2

Sampling wastes should be managed in a manner that reduces contact with the environment. Wastewater could be stored in 55-gallon drums and disposed of appropriately. RI waste management practices could be continued for this alternative.

Implementability

Monitored natural attenuation is technically feasible and easily implemented. Monitoring and modeling intrinsic groundwater remediation is the essential component of monitored natural attenuation. Implementation of the initial screening process is both technically and administratively feasible While monitored natural attenuation is reliable (except when degradation results in more toxic products), screening and modeling can determine if monitored natural attenuation can reduce contaminants to RGs in a reasonable time (less than five years). No construction, operation, or maintenance issues are initially involved with this alternative Current access controls - including military security and limited personnel access - have been reliable in the past No administrative coordination would be required to implement the monitored natural attenuation alternative Monitored natural attenuation would not require offsite treatment services materials or innovative technologies

Cost

Cost components for the monitored natural attenuation alternative include the following.

- Initial monitored natural attenuation assessment
- Fate-and-transport modeling
- Groundwater sampling and analysis
- Engineering, institutional controls, and report compilation

Costs associated with monitored natural attenuation are detailed in Section 8.5.2. Capital costs for Alternative G2 initial screening and startup — including direct, indirect and incidentals — are approximately $313,600. Annual operating and maintenance costs for monitored natural attenuation long-term monitoring are $65,900. Assuming a 25% contingency and RAC costs, the total present value for Alternative G2 is $1,320,700 (assuming a 6% discount rate over 30 years).

Modifying Criteria

State/Support Agency Acceptance

FDEP and the USEPA are involved in the partnering team process and will both have the opportunity to review and comment on this FS.

Community Acceptance

Community acceptance for Alternative G2 would be established after the public-comment period for the FS. Education of the public on the difference between monitored natural attenuation and no action might be required, if monitored natural attenuation is selected as the remedial alternative This criterion is generally not completed until after public comments on the RI/FS report and the proposed plan are received

8.6.3 Alternative G3· Phytoremediation

In this alternative, phytoremediation would include research, bench and pilot-scale feasibility testing, and planting and monitoring over approximately three acres. Institutional controls would be required to prevent domestic use since PQG criteria are the site RGs

Threshold Criteria

Overall Protection of Human Health and the Environment

Phytoremediation protects human health and the environment by slowly removing, transforming, or immobilizing contaminants in the groundwater. This alternative, coupled with appropriate institutional controls, would eliminate risk to future site workers and the environment and drastically reduce the potential for continued contaminant migration.

Short-term risks from inhalation and dermal contact during implementation would be minimal and could be controlled using common engineering techniques and appropriate PPE. This alternative would comply with applicable waste management standards and chemical-specific regulations.

Phytoremediation is still in the early stages of development. As such, long-term reliability and effectiveness are relatively unknown. However, substantial research is underway and results are promising.

Finally, public acceptance of phytoremediation can be very high, in part because of the park-like aesthetic, which includes bird and wildlife habitats

Compliance with ARARs

Phytoremediation is intended to comply with the chemical-specific ARARs developed in Section 8 1 ARARs that identify alternative cleanup target levels based on poor quality groundwater include Florida Rules 62-770, 62-781 and 62-785. Phytoremediation is the one of the least aggressive remedial technology under consideration and will likely require years to attain proposed cleanup standards. Wetland mitigation ARARs may be triggered since remedial actions would be implemented adjacent to the Bayou Grande These location specific ARARs include the following:

- Flood plain requirements as outlined in the *National Environmental Policy Act* (40 CFR Part 6, Appendix A).

- Requirements for wetland endangered species as outlined in the *Endangered Species Act* (50 CFR Part 402 and Part 200).

No action-specific ARARs are triggered by groundwater Alternative G3. However, Florida Proposed Rule 62-777 is a potential ARAR for Site OU 2.

Balancing Criteria

Long-term Effectiveness and Permanence

Use of phytoremediation is currently limited to research activities and limited field testing. While several recent and on-going applications have reportedly been successful in lowering contaminant concentrations, complete full-scale applications of this innovative technology projects are scarce Reported results show some potential for practical applications of these techniques to achieve remedial objectives and regulatory approval; however, at least two or three more years of field tests are necessary to validate the initial, small-scale field tests.

The consumption of contaminated groundwater would be controlled institutionally and groundwater would be monitored until remedial goals are met Controls currently in place at the site – which include military security and limited site access and use would remain. Due to the abundant supply of high quality water in the deeper main producing zone, groundwater from the surficial zone is not used as a potable water source in southern Escambia County, nor is it expected to be used in the future. The base receives its potable water from Corry Station, which is approximately three miles away

Reduction of Toxicity, Mobility, or Volume Through Treatment

This alternative would provide effective toxicity, mobility, or volume reduction by slowly removing, transforming, or immobilizing groundwater contaminants. Current site conditions are amenable to phytoremediation. However, since phytoremediation is an emerging technology, its effectiveness at this site is not known. This alternative may generate more toxic treatment residuals. Furthermore, the trees or plants may require periodic harvesting, which may trigger additional solid or hazardous waste considerations.

Short-term Effectiveness

The phytoremediation operation would be sufficiently removed from the public to reduce health and safety concerns associated with groundwater remediation. The community is protected through groundwater restrictions and institutional controls. Workers are protected by groundwater restrictions, equipment, and training. Workers may be exposed to increased particulate emissions during planting and grading activities and might also have more dermal contact with hazardous constituents. However, worker risks can be reduced by implementing dust control technologies and a site-specific health and safety plan specifying PPE, respiratory protection, etc.

Implementability

Phytoremediation is technically and administratively feasible at Sites 11, 12, and 26. Areas to be remediated are readily accessible. The groundwater contaminants are very shallow (< 3 feet bgs), which contributes to phytoremedial success. Overall, this alternative is easy to install, maintain, and monitor Only landscaping equipment would be required to implement this technology. Confirmatory sampling would be required to monitor its performance of the process. No future remedial actions would be required after this alternative is completed. Institutional controls would be required

Cost

Costs associated with this alte native are detailed in Section 8 5 Capital costs for phytoremediation, which include laboratory/pilot/field studies, planting and soil amendments, institutional controls, and indirect costs, are $242,900. Annual operating and maintenance costs for this alternative are $13,000 Long-term monitoring's annual costs are $65,900. Assuming a 25% contingency and RAC costs, the total present value for Alternative G3 is $1,428,900 (assuming a 6% discount rate over 30 years).

Modifying Criteria

State/Support Agency Acceptance

FDEP and the USEPA are involved in the partnering team process and will both have the opportunity to review and comment on this FS. If phytoremediation reduces contaminants to RGs in a reasonable time (less than five years), regulatory concurrence for this alternative is expected.

Community Acceptance

Community acceptance for the no-action alternative would be established after the public-comment period.

8.6.4 Alternative G4: Groundwater Extraction and Disposal to FOTW

This alternative involves recovering groundwater by well extraction, then discharging it to the FOTW. Mass removal from the shallow aquifer in Sites 11, 12, and 26 would protect downgradient receptors. Alternative G4 would contain both areas of concern using two proposed recovery wells located at well 11GM47 and near well cluster 11GS13, 11GM52, and 11GI14. Institutional controls would also be implemented at Sites 11, 12, and 26 for this alternative.

Threshold Criteria

Overall Protection of Human Health and the Environment

Human health is protected by containing groundwater in which contaminants exceed PQG criteria, thus preventing contaminant migration beyond the source area, and removing mass in contaminated zones

Extracted groundwater would discharge to the FOTW. Institutional controls would limit groundwater use.

Compliance with ARARs

Groundwater extraction complies with the chemical-specific ARARs developed in Section 8.1. Florida Proposed Rule 62-777 is also a potential ARAR for OU 2. ARARs that identify alternative cleanup target levels based on poor quality groundwater include Florida Rules 62-770, 62-781, and 62-785. The contaminated groundwater would be captured by extraction wells, thereby removing groundwater in which contaminants exceed PQG criteria. Removal of groundwater from Sites 11, 12, and 26 is intended to reduce the mass of contaminants in the aquifer and contain the groundwater areas of concern. Location- and action-specific ARARs include the following:

- Flood plain requirements as outlined in the *National Environmental Policy Act* (40 CFR Part 6, Appendix A).

- Requirements for wetland endangered species as outlined in the *Endangered Species Act* (50 CFR Part 402 and Part 200).

- Pretreatment and discharge requirements for waste water as outlined in the *Florida Industrial Waste Water Facilities* (Chapter 62-660), *Florida Water Quality Based Effluent Limitations* (Chapter 62-650), *Florida Pretreatment Requirements for Existing and New Sources of Pollution* (Chapter 62-625), and *Florida Waste Water Facility Permitting* (Chapter 62-620)

The FOTW is subject to NPDES requirements and FOTW effluent discharges must meet permit requirements

Balancing Criteria

Long-term Effectiveness and Permanence

Groundwater extraction would contain contaminants and reduce groundwater contamination by mass removal. Groundwater migration is expected to be arrested by the containment system. Alternative G4 reduces risk through mass removal and offers protection by containing the source. Furthermore, groundwater monitoring effectively assesses mass reduction and contaminant migration potential from areas not contained by groundwater extraction. A groundwater sampling and monitoring program will be developed after five pore volumes have been extracted.

For the purpose of the FS, the projected remedial time to withdraw five pore volumes is three years. Risks to human health and the environment onsite are expected to decrease with time as constituents are removed. Saline intrusion from groundwater extraction is not likely because the relatively low pumping rates should not draw from nearby saltwater bodies.

Reduction of Toxicity, Mobility, or Volume Through Treatment

This alternative is a mass removal/containment alternative. Groundwater removal at Sites 11, 12, and 26 would reduce groundwater toxicity and contaminant volume. Groundwater containment eliminates contaminant migration. This alternative also reduces mobility or volume through mass removal. Over three years, Alternative G4 would extract an estimated 24 million gallons of groundwater from Sites 11, 12, and 26. Assuming no requirement for pretreatment, this water would be collected and discharged to the FOTW. Mass removal of chlorinated hydrocarbons and primary metals from the surficial aquifer is expected to be permanent.

Short-Term Effectiveness

Adverse impacts to the surrounding environment are not anticipated during groundwater recovery system construction Approval to discharge to the FOTW needs to be obtained before implementation. After design plans are approved and testing is complete, the groundwater collection system would be constructed Collection of five pore volumes is estimated to take three years

Workers exposed to risks should be trained according to OSHA standards as required by 29 CFR 1910 120 to protect and mitigate risks during remedial construction. Field personnel contact with site contaminants would be minimal during construction (pump installation, control panel installation, and sanitary sewer connections). Workers could be protected by wearing appropriate PPE. Compliance with RGs can be determined by monitoring site wells. System performance and mass removal can be evaluated by effluent monitoring. Alternative G4 would be compatible with any additional remedial actions, if required.

Implementability

Extracting contaminated groundwater beneath the site is both technically and administratively feasible. This alternative would not require any extraordinary services, materials, specialists, or innovative technologies. Construction and operation could be achieved with minimal difficulty. Implementation could begin immediately.

Cost

Direct and indirect costs associated with groundwater extraction Alternative G4 are $240,200. Annual operation, maintenance, and FOTW costs are expected to be S67,000 (including groundwater monitoring). The total present value cost of Alternative G4, including implementing institutional controls and the costs for the corrective action contractor, is estimated to be $519,300 (assuming a 6% discount rate over three years).

Modifying Criteria

State/Support Agency Acceptance

FDFP and the USEPA will have the opportunity to review and comment on this proposed plan.

Community Acceptance

These criteria are generally not completed until after public comments on the RI/FS report and the proposed plan are received

8.6.5 Alternative G5: Groundwater Extraction and Air Stripping with Inorganics Pretreatment

This alternative involves recovering groundwater by well extraction. Extracted groundwater is then treated onsite and discharged to the FOTW. The treatment technologies identified for groundwater are chemical/physical processes for chlorinated hydrocarbons and primary and secondary heavy metals. Area remediation would remove a potential source of downgradient contamination, and permit natural flushing and attenuation of contaminated plumes. Three treatment systems have been evaluated — air stripping with a pretreatment unit: (a) coagulation/precipitation, (b) membrane filtration, or (c) ion exchange. This alternative also includes institutional controls for PQG RGs

Threshold Criteria

Overall Protection of Human Health and the Environment

Human health is protected by extracting, containing, and treating groundwater in which contaminants exceed PQG criteria for chlorinated hydrocarbons and heavy metals, thus preventing contaminant migration beyond the source area and effecting mass removal in contaminated zones. Extracted groundwater would be treated before discharge to the FOTW. Institutional controls would limit groundwater use.

Compliance with ARARs

Groundwater extraction and treatment complies with the chemical-specific ARARs developed in Section 8 1 Florida Proposed Rule 62-777 is also a potential ARAR for OU 2. ARARs that dentify alternative cleanup target levels based on poor quality groundwater include Florida Rules 62-770, 62-781, and 62-785 The contaminated groundwater would be captured by extraction wells and treated thus removing compounds that exceed PQG criteria Groundwater removal from Sites 11, 12 and 26 is intended to reduce the mass of contaminants in the aquifer and contain the two groundwater areas of concern

Waste disposal standards for waste generated from the treatment system would be triggered; specific waste disposal ARARs depend on sludge characteristics. Both federal and Florida action-specific ARARs would be met by Alternative G5. Hazardous materials may be treated or stored onsite as a result of remedial activity and proper management of these materials in accordance with Florida Hazardous Waste Rules would be required. Location- and action-specific ARARs include the following:

- Flood plain requirements as outlined in the *National Environmental Policy Act* (40 CFR Part 6, Appendix A).

- Requirements for wetland endangered species as outlined in the *Endangered Species Act* (50 CFR Part 402 and Part 200).

- Treatment residuals requirements as outlined in the *RCRA Identification of Hazardous Waste* (40 CFR 261), *RCRA Generator Standards* (40 CFR 262), *RCRA Facility Standards* (40 CFR 264), *RCRA Land Disposal Restrictions* (40CFR 268), *DOT Rules for the Transport of Hazardous Substances* (49 CFR Parts 107 and 171-179), and *Florida Hazardous Waste Rules* (Chapter 62-730).

- Requirements for air emissions as outlined in the *Clean Air Act Permits Regulation* (40 CFR 72) and *Florida Air Pollution Rules* (Chapters 62-210, 62-212, 62-213, and 62-296)

- Discharge and pretreatment requirements as outlined in the *Clean Water Act General Pretreatment regulations for Existing and New Sources of Pollution* (40 CFR 403), *Florida Industrial Waste Water Facilities* (Chapter 62-660), *Florida Water Quality Based Effluent Limitations* (Chapter 62-650) *Florida Pretreatment Requirements for Existing and New Sources of Pollution* (Chapter 62-625), *Florida Waste Water Facility Permitting* (Chapter 62-620)

The FOTW is subject to NPDES requirements and all FOTW effluent must meet these requirements.

Balancing Criteria

Long-term Effectiveness and Permanence

Groundwater extraction and treatment would contain contaminants and reduce chlorinated hydrocarbon and heavy metals concentrations through mass removal. Groundwater migration is expected to be arrested by the containment system. Groundwater extraction removes contaminants from the surficial zone and contains plume areas. This alternative effectively removes contaminant mass. Ex situ groundwater treatment removes contaminants. Furthermore, groundwater monitoring effectively assesses mass reduction and contaminant migration potential from areas not contained by groundwater extraction. A groundwater sampling and monitoring program will be developed after five pore volumes have been extracted.

Reduction of Toxicity, Mobility, or Volume Through Treatment

This alternative removes and contains mass. Groundwater removal at Sites 11, 12, and 26 would reduce its toxicity and contaminant volume.

Air stripping and the proposed chemical and physical treatment units are established technologies for removing contaminants. Inorganic compounds (primary and secondary metals) would be separated in a sludge or concentrated liquid and disposed of offsite. Groundwater containment eliminates contaminant migration. This alternative reduces toxicity, mobility or volume through treatment, and satisfies the statutory preference for treatment as a principal element The FOTW also provides additional treatment

Over three years, Alternative G5 would extract an estimated 24 million gallons of groundwater, which would be collected and discharged to the FOTW Flow rate estimates based on preliminary modeling, are 7.5 gpm for each of the two wells. Mass removal of contaminants in the surficial aquifer is expected to be permanent.

Short-Term Effectiveness

Adverse impacts to the surrounding environment are not anticipated during groundwater recovery and treatment system construction. The FOTW needs to accept discharge before implementation. After design plans are approved and testing is complete, the groundwater collection system would be constructed. Collection of five pore volumes is estimated to take three years.

Field personnel contact with site contaminants would be minimal during construction (pump installation, control panel installation, and sanitary sewer connections). Worker protection could be managed through use of appropriate PPE and implementation of a HASP.

Compliance with RGs can be determined by monitoring site wells. System performance and mass removal can be evaluated by effluent monitoring. Alternative G5 would be compatible with any additional remedial actions required.

Implementability

Extracting contaminated groundwater from beneath the site and providing treatment is both technically and administratively feasible. This alternative would not require any extraordinary services, materials, specialists, or innovative technologies. Construction and operation could be achieved with minimal difficulty. Offsite disposal would be required for solids or concentrated liquids generated by the treatment processes. Implementation could begin immediately.

Cost

Costs are discussed in two groups (1) groundwater recovery and (2) groundwater treatment:

- *Alternative G5 Groundwater Recovery* Direct and indirect costs associated with groundwater extraction for Alternative 5a 5b, and 5c are $240,200 (includes institutional controls aquifer testing, and FOTW cooperation). Annual maintenance costs are expected to be $67,000.

- *Alternative G5a: Air Stripping with Coagulation/Precipitation*: Direct and indirect capital costs for air stripping and physical/chemical treatment for Alternative G5a are $1,388,500. Annual operating costs for treatment are expected to be $178,000; annual disposal costs are estimated to be $34,100. The total present value of air stripping with coagulation/precipitation is $1,955,400 — S2,474,700 including groundwater recovery (assuming a 6% discount rate over three years).

- *Alternative G5b: Air Stripping with Membrane Filtration:* Direct and indirect capital costs for air stripping and physical/chemical treatment for Alternative G5b are $729,500. Annual operating costs for treatment are expected to be $158,000; annual disposal costs are estimated to be $34,100. The total present value of air stripping with membrane filtration is $1,242,900 — $1,762,200 including groundwater recovery (assuming a 6% discount rate over three years).
- *Alternative G5c: Air Stripping with Ion Exchange:* Direct and indirect capital costs for air stripping and physical/chemical treatment for Alternative G5c are $816,500. Annual operating costs for treatment are expected to be $228,000; annual disposal costs are estimated to be $72,500 The total present value of air stripping with ion exchange is $1,619,700 — $2,139,000 including groundwater recovery (assuming a 6% discount rate over three years)

Modifying Criteria

State/Support Agency Acceptance

FDEP and the USEPA will have the opportunity to review and comment on this FS

Community Acceptance

These criteria are generally not completed until after public comments on the RI/FS report and the proposed plan are received.

8.7 Comparative Analysis of Alternatives

The five groundwater remedial alternatives are comparatively analyzed based on the nine criteria, and summarized in Table 8 18.

Table 8-18
Comparative Analysis of Groundwater Alternatives

Evaluation Criteria	Alternative G1	Alternative G2	Alternative G3	Alternative G4	Alternative G5
Threshold Criteria					
Protection of human health and the environment (HH&E)	No action is implemented to protect HH&E. Without action, current conditions are not protective.	Restrictions on groundwater use and attenuation of contaminant concentrations will protect HH&E.	Protects HH&E by slowly removing, transforming, or immobilizing contaminants in the groundwater.	Protects HH&E through groundwater containment and removal.	Protects HH&E through groundwater containment, removal, and treatment.
Compliance with ARARs	Does not comply with ARARs.	Exceedances are monitored to ensure compliance over time.	Exceedances are monitored to ensure compliance over time.	Complies with ARARs through mass removal.	Complies with ARARs through mass removal and treatment.
Balancing Criteria					
Long-term effectiveness and permanence	None.	Attenuation is a slow process — therefore, long-term effectiveness may be minimal.	Limited to research activities and limited field testing.	Groundwater contaminant migration is expected to be arrested by the containment system.	Groundwater contaminant migration is expected to be arrested by the containment system. Treatment is expected to destroy contaminants.
Reduction of toxicity, mobility, or volume through treatment	None.	Toxicity, mobility, and volume are reduced via natural processes.	Toxicity, mobility, and volume are reduced via degradation or immobilization.	Reduces toxicity, mobility, and volume through mass removal.	Reduces toxicity, mobility, and volume through mass removal and treatment.

Table 8-18
Comparative Analysis of Groundwater Alternatives

Evaluation Criteria	Alternative G1	Alternative G2	Alternative G3	Alternative G4	Alternative G5
Short-term effectiveness:	No risks are associated with no-action.	No risks are associated with MNA.	Groundwater restrictions, institutional and engineering controls, and a site-specific HASP will provide short-term effectiveness.	Adverse impacts to surrounding environment are not anticipated during groundwater recovery system construction.	Adverse impacts to surrounding environment are not anticipated during groundwater recovery system construction.
Implementability	Technically and administratively feasible. Easily implemented.	Technically and administratively feasible. Easily implemented.	Technically and administratively feasible. Easy to install, maintain, and monitor.	Technically and administratively feasible. Requires routine system O&M.	Technically and administratively feasible. Requires routine system O&M. Offsite disposal of sludge required.
Cost	**Capital:** none **Annual:** $48,100 (every five years) **PW:** $117,500	**Capital:** $313,600 **Annual:** $65,900 **PW:** $1,320,700	**Capital:** $242,900 **Annual:** $78,900 **PW:** $1,426,900	**Capital:** $240,200 **Annual:** $67,000 **PW:** $519,300	**Capital:** $969,700 to $1,628,700 **Annual:** $259,100 to $367,500 **PW:** $1,762,200 to $2,474,700

Table 8-18
Comparative Analysis of Groundwater Alternatives

Evaluation Criteria	Alternative G1	Alternative G2	Alternative G3	Alternative G4	Alternative G5
Modifying Criteria					
State support and agency acceptance	FDEP and USEPA will have an opportunity to review and comment on this technology.	FDEP and USEPA will have an opportunity to review and comment on this technology.	FDEP and USEPA will have an opportunity to review and comment on this technology.	FDEP and USEPA will have an opportunity to review and comment on this technology.	FDEP and USEPA will have an opportunity to review and comment on this technology.
Community acceptance	Community acceptance would be established after comment period.	Community acceptance will be determined after the public-comment period. Public education on the difference between no-action and MNA may be required.	Community acceptance would be established after comment period.	Community acceptance would be established after comment period.	Community acceptance would be established after comment period.

Notes:
Alternative G1 = No-action
Alternative G2 = Monitored natural attenuation
Alternative G3 = Phytoremediation
Alternative G4 = Groundwater extraction and disposal to the FOTW
Alternative G5 = Groundwater extraction and air stripping with inorganics pretreatment
PW = present worth

9.0 SITES 25, 27, AND 30 GROUNDWATER FEASIBILITY EVALUATION

Groundwater concentrations have been compared to ARARs — FPDWS, FSDWS, FSWQs, MSWQs, and PQGs. All exceedances reported in the RI were reviewed to determine whether they indicated a contaminant plume or mass that poses a risk to human health or the environment. Groundwater was assessed to delineate areas requiring feasibility study.

To discuss ARAR exceedances, groundwater has been discussed site-by-site. Sites 11, 12, and 26 and Sites 25, 27, and 30 have been grouped together to better understand where exceedances occur and to facilitate remedial planning for groundwater at OU 2. Sites 11, 12, and 26 were discussed together in Section 8; exceedances at Sites 25, 27, and 30 are discussed in Section 9.

Naturally occurring inorganic compounds in the shallow aquifer have been detected in background samples at concentrations indicating a poor water quality aquifer, not a *usable* drinking water source As such, primary (sodium) and secondary inorganic compounds (aluminum, calcium, copper, iron, magnesium, manganese and vanadium) that exceeded FPDWS and FSDWS criteria were excluded from groundwater exceedance evaluations since their concentrations are typical of natural conditions. While these compounds may affect remedial technology selection and design, they are not considered significant environmental concerns.

Moreover, in general, total metals concentrations (primary and secondary metals) were significantly lower during Phase II sampling and reasonably commensurate to background concentrations when low-flow sampling techniques were used in place of traditional bailing. Therefore, it was concluded that elevated metals concentrations detected relatively site wide during Phase I were induced by sampling rather than actual aquifer conditions.

Inorganic compounds that exceeded secondary criteria are listed in Appendix B.

9.1 Nature of Contamination

9.1.1 Site 25 ARAR Exceedances

Comparison with FPDWS and FSDWS Criteria

Phase I

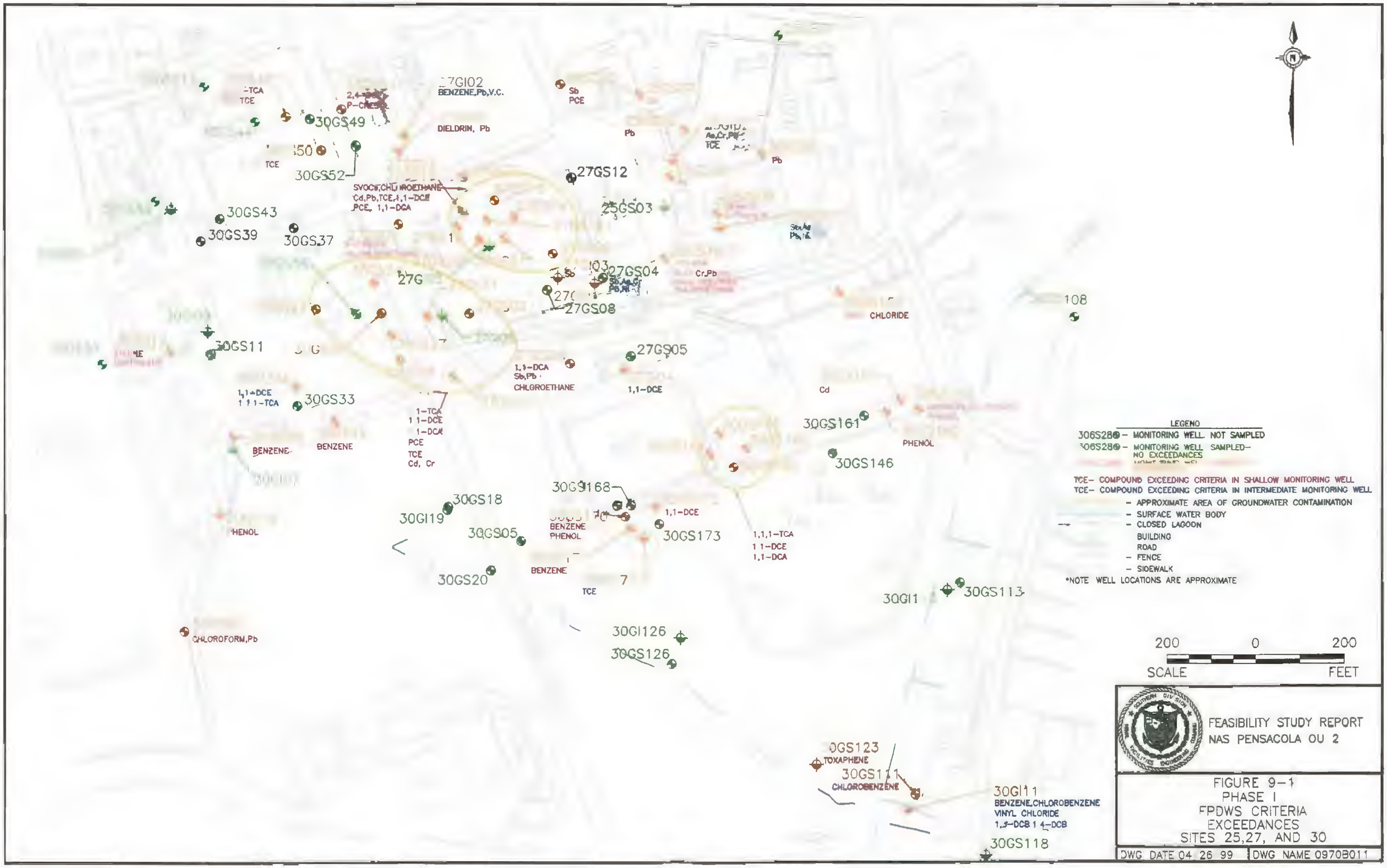
In samples from every shallow and intermediate well, contaminants exceeded at least one FPDWS and FSDWS criteria. However, only eight of nine shallow wells had groundwater exceedances when secondary metals were excluded. The contaminants that exceeded FPDWS criteria were primary metals (antimony, arsenic, cadmium, chromium, lead, mercury, and nickel) and VOCs (1,1-DCA, chloroethane, tetrachloroethene, and vinyl chloride). Metals (particularly cadmium, chromium, and lead) exceeded their criteria across the site VOC exceedances in two wells (25GS02 and 25GS04) may indicate contamination that also affects Sites 27 and 30

In samples from each intermediate well contaminants exceeded at least one FPDWS and FSDWS criteria The contaminants that exceeded FPDWS criteria are primary metals (antimony, arsenic, cadmium chromium, lead and nickel) and TCE.

Site 25 wells in which contaminants exceeded FPDWS criteria during Phase I sampling are shown on Figure 9-1.

Phase II

Contaminants in three of six shallow wells and every intermediate well exceeded at least one FPDWS and FSDWS criteria. However, only one of six shallow wells had any FPDWS criteria exceedances when secondary metals were excluded. Mercury exceeded its FPDWS criteria in shallow well 25GS09 in the southern portion of the site. Low-flow sampling techniques used during Phase II sampling may have contributed to fewer metals exceedances by significantly reducing turbidity in the shallow and intermediate well samples.



FEASIBILITY STUDY REPORT
NAS PENSACOLA OU 2

FIGURE 9–1
PHASE I
FPDWS CRITERIA
EXCEEDANCES
SITES 25,27, AND 30

DWG DATE 04 26 99 | DWG NAME 0970B011

TCE exceeded its FPDWS criteria in each intermediate well. Site 25 wells exceeding FPDWS criteria during Phase II are shown on Figure 9-2.

Based on Phase I and II sampling, VOC exceedances may indicate of contamination that also affects Sites 27 and 30. Table 9-1 lists the locations and compounds exceeding the FPDWS.

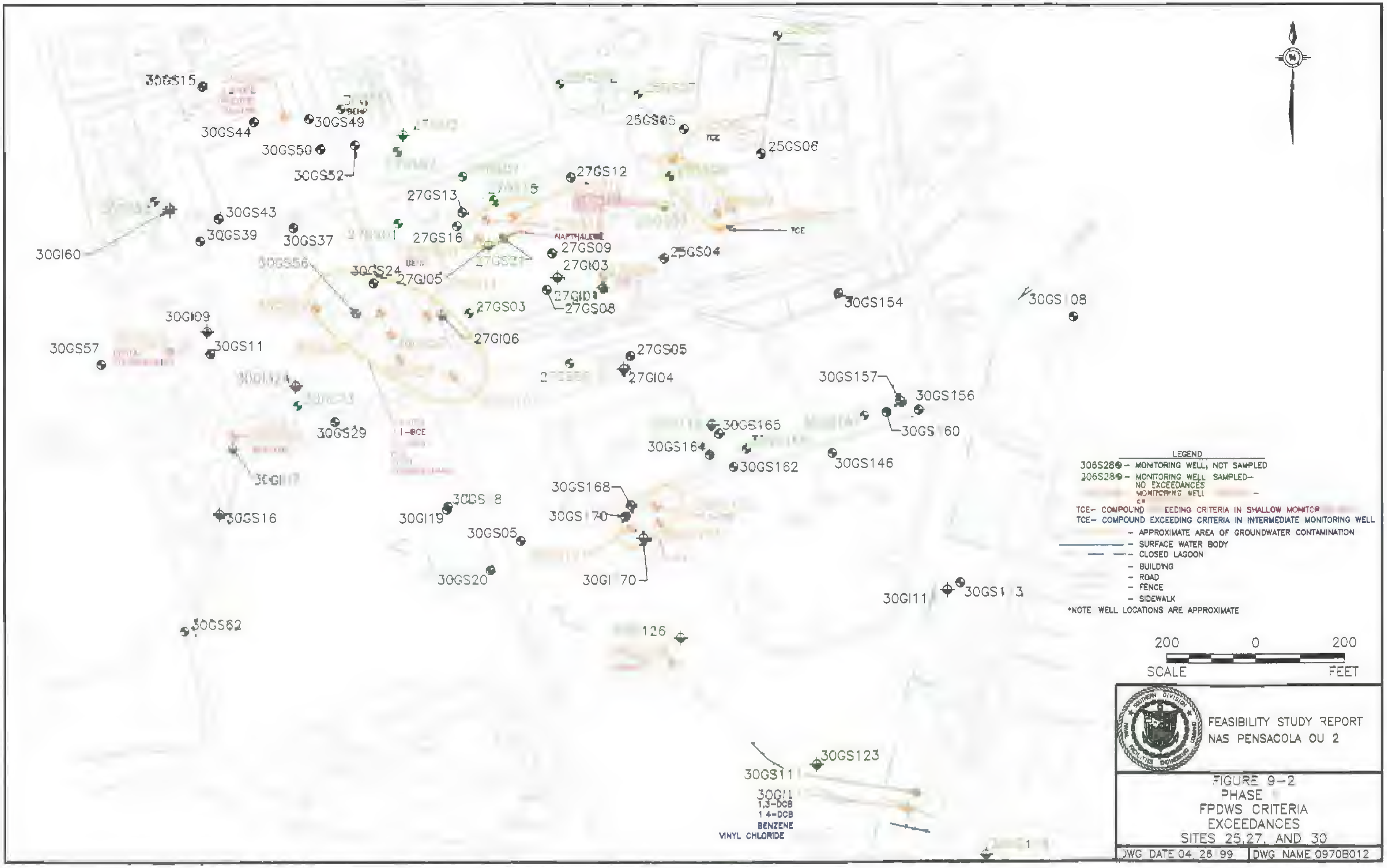
Table 9-1
Site 25 FPDWS Criteria Exceedances, Phases I and II

Sample ID	Parameter	Result ($\mu g/L$)	
25GI0101	Antimony	53.4	J
	Arsenic	142.0	J
	Cadmium	6.1	
	Chromium	225.0	
	Lead	45.7	J
	Nickel	112.0	
	Trichloroethene	14.0	
25GI0102	Trichloroethene	17.0	
25GI0201	Arsenic	64.9	
	Chromium	231.0	
	Lead	28.3	
	Trichloroethene	5.0	J
25GI0202	Trichloroethene	10.0	
25GS0200	Antimony	61.0	J
	Tetrachloroethene	5.0	J
25GS0300	Antimony	65.4	J
	Lead	28.8	J
25GS0400	1,1-dichloroethane	90.0	
	Antimony	218.0	J
	Cadmium	54.4	
	Chloroethane	44.0	
	Chromium	14700.0	
	Lead	394.0	J
	Mercury	2.4	
	Vinyl chloride	7.0	J
25GS0500	Lead	16.0	
25GS0600	Lead	40.0	

Table 9-1
Site 25 FPDWS Criteria Exceedances, Phases I and II

Sample ID	Parameter	Result (μg/L)
25GS0700	Cadmium	5.4
25GS0800	Lead	55.9
25GS0900	Antimony	43.7 J
	Arsenic	85.7 J
	Cadmium	7.9
	Chromium	574.0
	Lead	308.0 J
	Mercury	2.3
	Nickel	107.0
25GS0902	Mercury	4.7

Notes:
J = Detected concentration is estimated.
μg/L = Micrograms per liter
Sample IDs ending in 00 or 01 indicate Phase I sampling results; sample IDs ending in 02 or 03 indicate Phase II sampling results.
Compound-specific criteria are provided in Appendix B.



FEASIBILITY STUDY REPORT
NAS PENSACOLA OU 2

FIGURE 9-2
PHASE
FPDWS CRITERIA
EXCEEDANCES
SITES 25,27, AND 30

DWG DATE 04 26 99 | DWG NAME 0970B012

Comparison with Freshwater Surface Water Quality

Phase I/Phase II

Since Site 25 is not adjacent to any freshwater body, contaminants in the shallow aquifer do not threaten any nearby surface water. Phase I and II FSWQ criteria exceedances for Sites 25, 27, and 30 are shown on Figures 9-3 and 9-4 respectively.

Comparison with Marine Surface Water Quality

Phase I/Phase II

Since Site 25 is not adjacent to any saltwater body, contaminants in the shallow aquifer do threaten any nearby surface water. Phase I and II MSWQ criteria exceedances for Sites 25, 27, and 30 are shown on Figures 9 5 and 9-6 respectively.

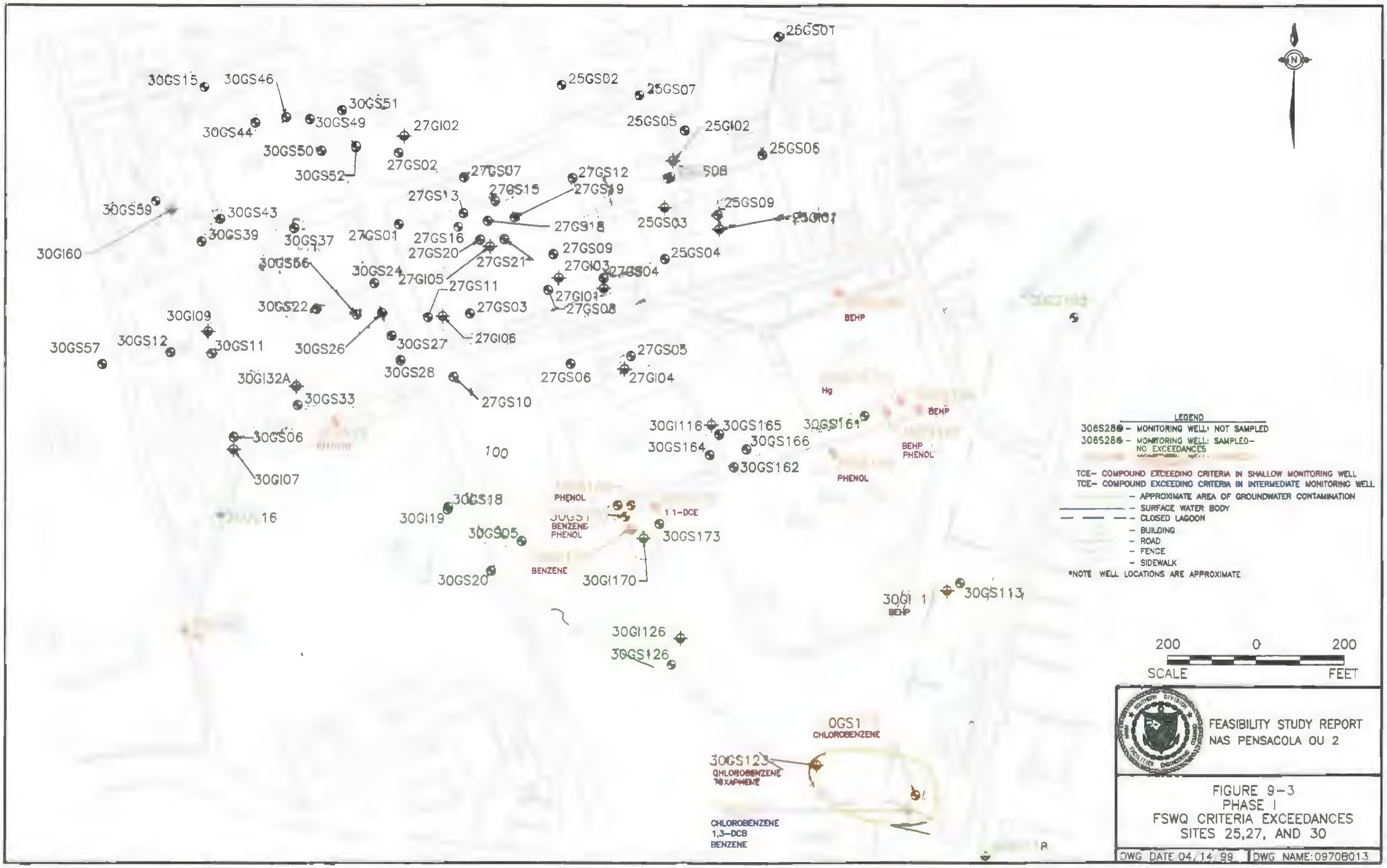
Comparison with Groundwater of PQG Criteria

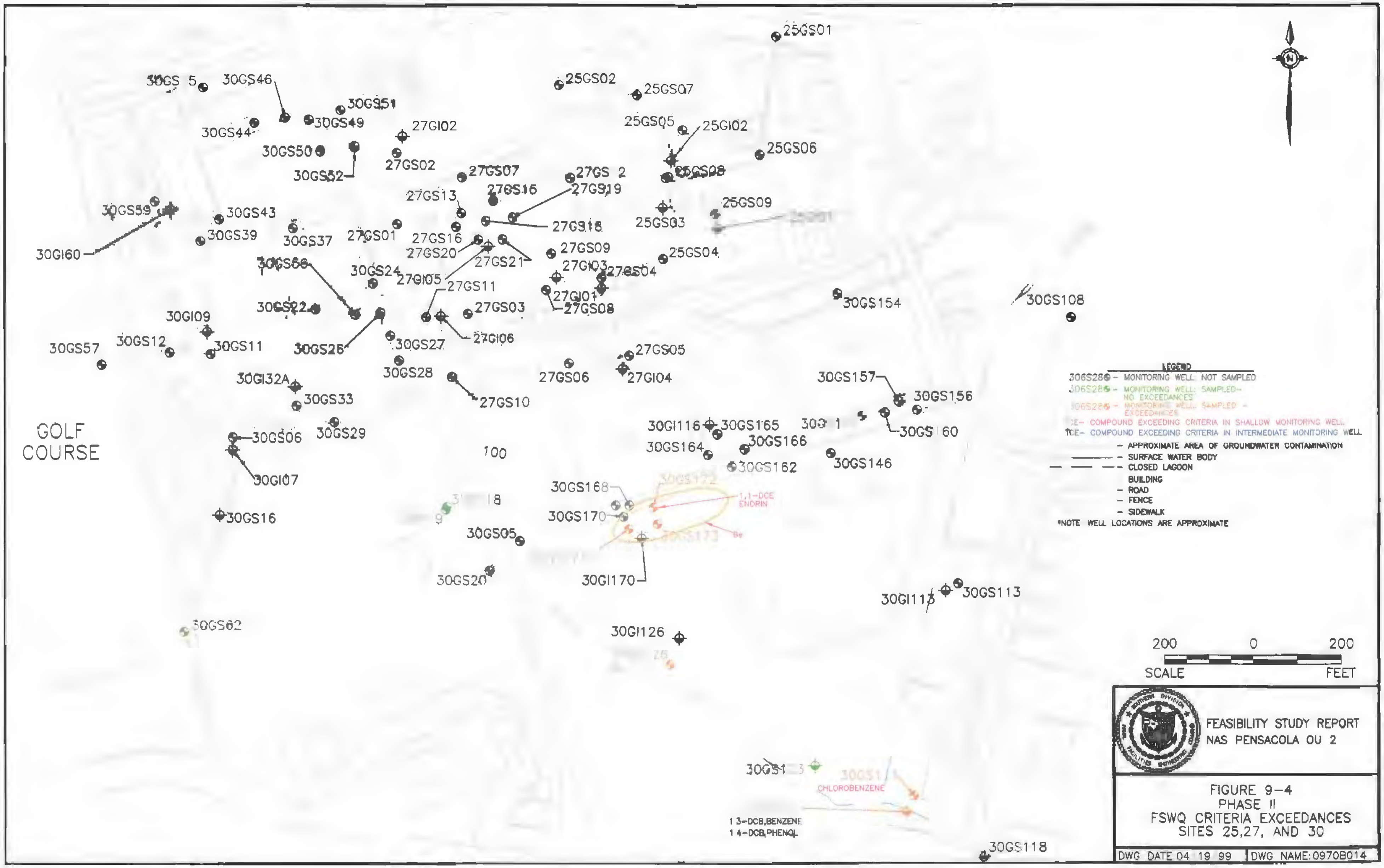
Phase I

Contaminants in every shallow and intermediate well had at least one or more PQG criteria exceedance. However, only four of nine shallow wells had any PQG criteria exceedances when secondary metals were excluded. The contaminants that exceeded PQG criteria were antimony, cadmium, chromium, and lead.

No intermediate wells had any PQG criteria exceedances when secondary metals were excluded.

Site 25 wells in which contaminants exceeded PQG criteria during Phase I are shown on Figure 9-7.

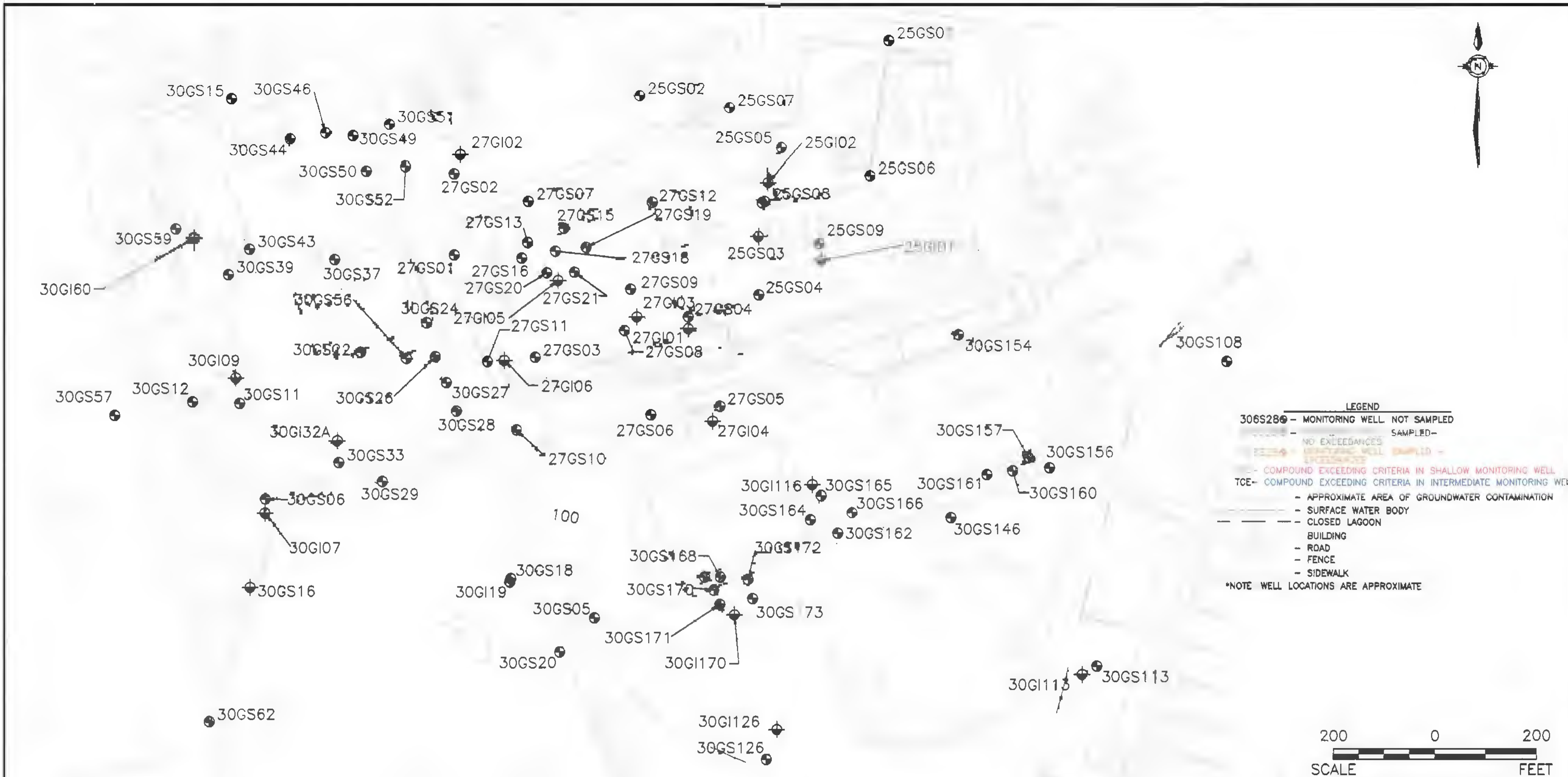

LEGEND
MONITORING WELL: NOT SAMPLED
MONITORING WELL: SAMPLED—NO EXCEEDANCES
TCE— COMPOUND EXCEEDING CRITERIA IN SHALLOW MONITORING WELL
TCE— COMPOUND EXCEEDING CRITERIA IN INTERMEDIATE MONITORING WELL
APPROXIMATE AREA OF GROUNDWATER CONTAMINATION
SURFACE WATER BODY
CLOSED LAGOON
BUILDING
ROAD
FENCE
SIDEWALK
*NOTE: WELL LOCATIONS ARE APPROXIMATE
SCALE
FEET
FEASIBILITY STUDY REPORT
NAS PENSACOLA OU 2
FIGURE 9-3
PHASE I
FSWQ CRITERIA EXCEEDANCES
SITES 25,27, AND 30
DWG DATE 04/14/99
DWG NAME: 0970B013



FEASIBILITY STUDY REPORT
NAS PENSACOLA OU 2

FIGURE 9-4
PHASE II
FSWQ CRITERIA EXCEEDANCES
SITES 25,27, AND 30

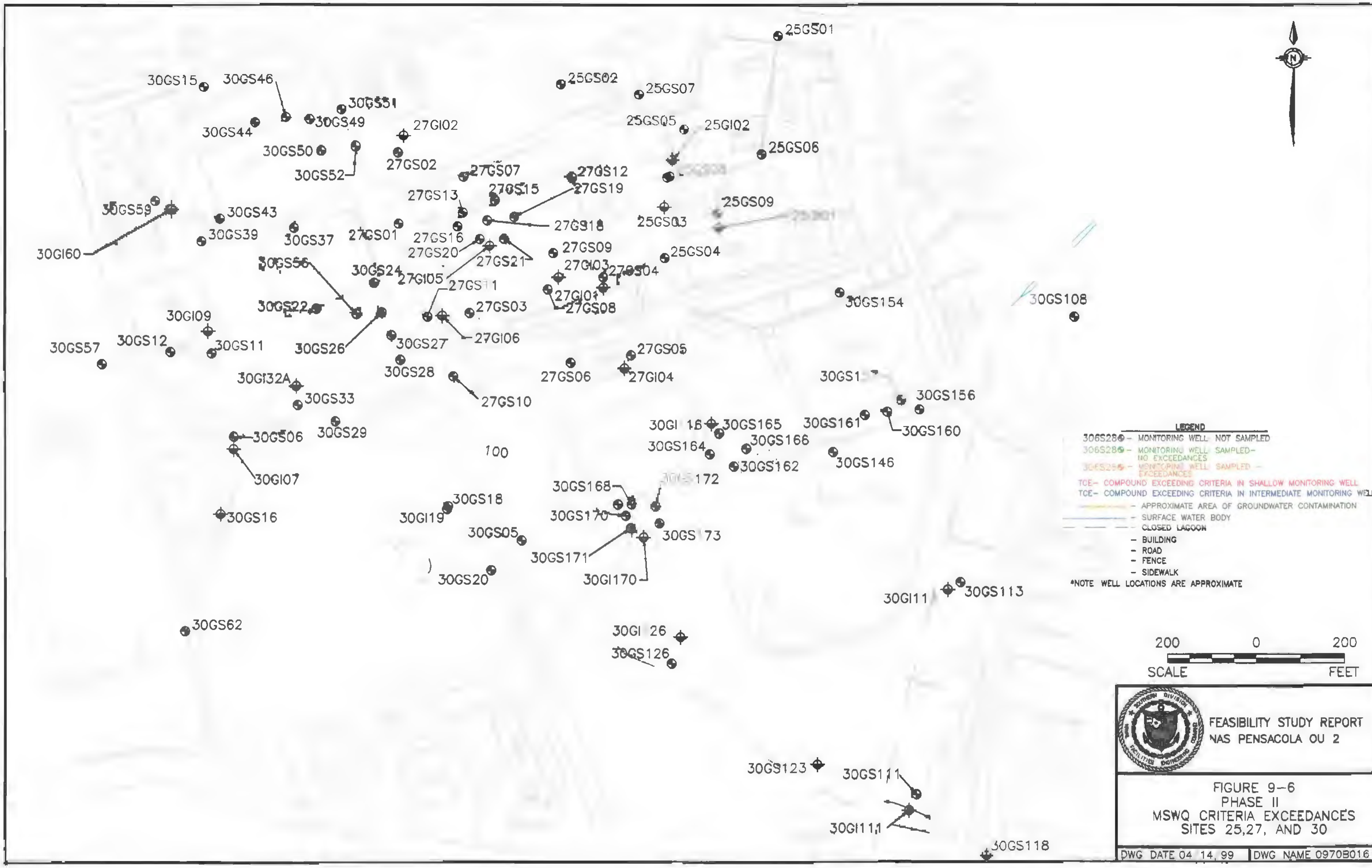
DWG DATE 04 19 99 | DWG NAME: 0970B014



FEASIBILITY STUDY REPORT
NAS PENSACOLA OU 2

FIGURE 9-5
PHASE I
MSWQ CRITERIA
EXCEEDANCES
SITES 25,27, AND 30

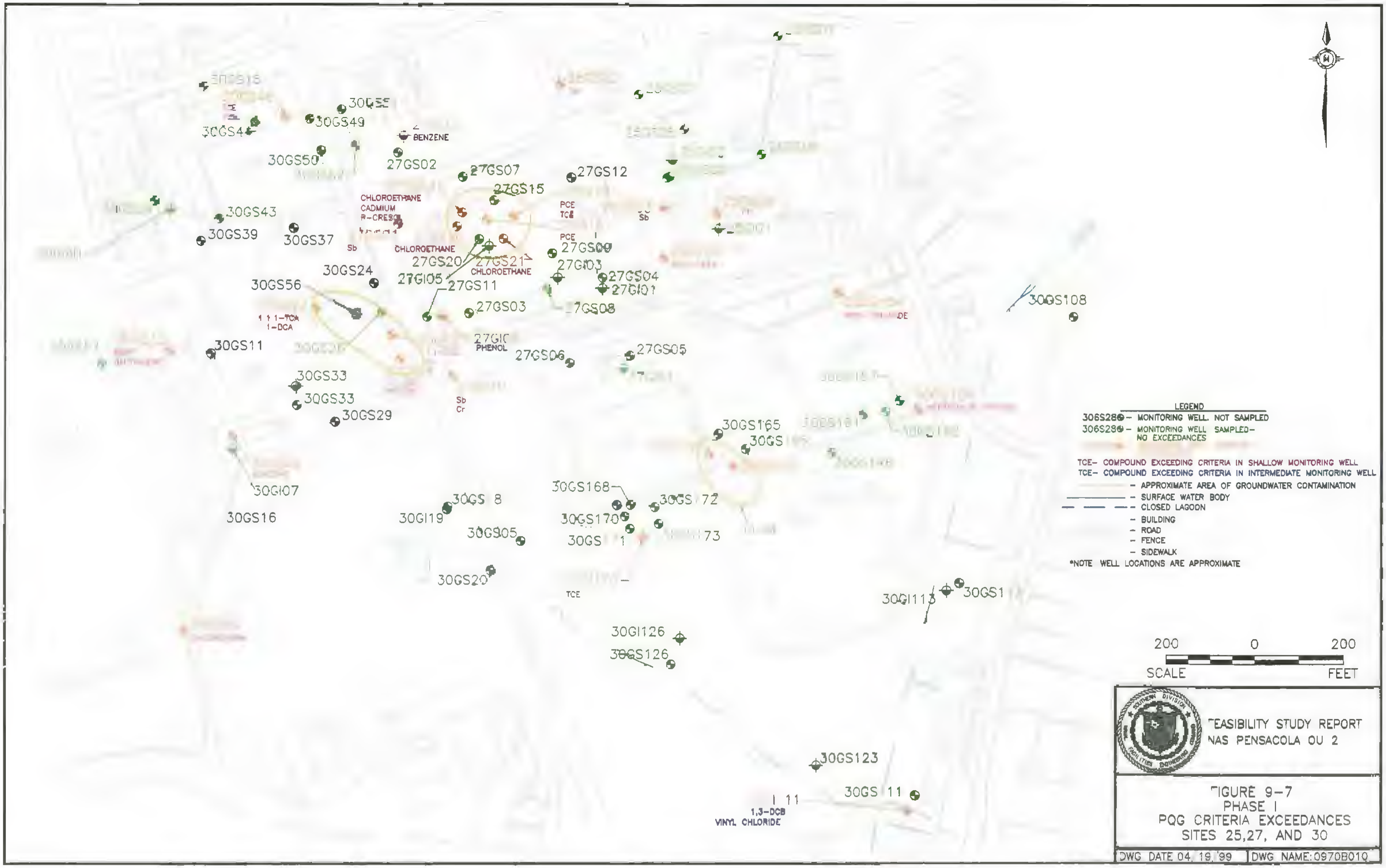
DWG DATE 04 19 99 | DWG NAME:0970B015



FEASIBILITY STUDY REPORT
NAS PENSACOLA OU 2

FIGURE 9–6
PHASE II
MSWQ CRITERIA EXCEEDANCES
SITES 25,27, AND 30

DWG DATE 04 14, 99 | DWG NAME 0970B016



FEASIBILITY STUDY REPORT
NAS PENSACOLA OU 2

FIGURE 9-7
PHASE I
PQG CRITERIA EXCEEDANCES
SITES 25,27, AND 30

DWG DATE 04/19/99 | DWG NAME: 0970B010

Phase II

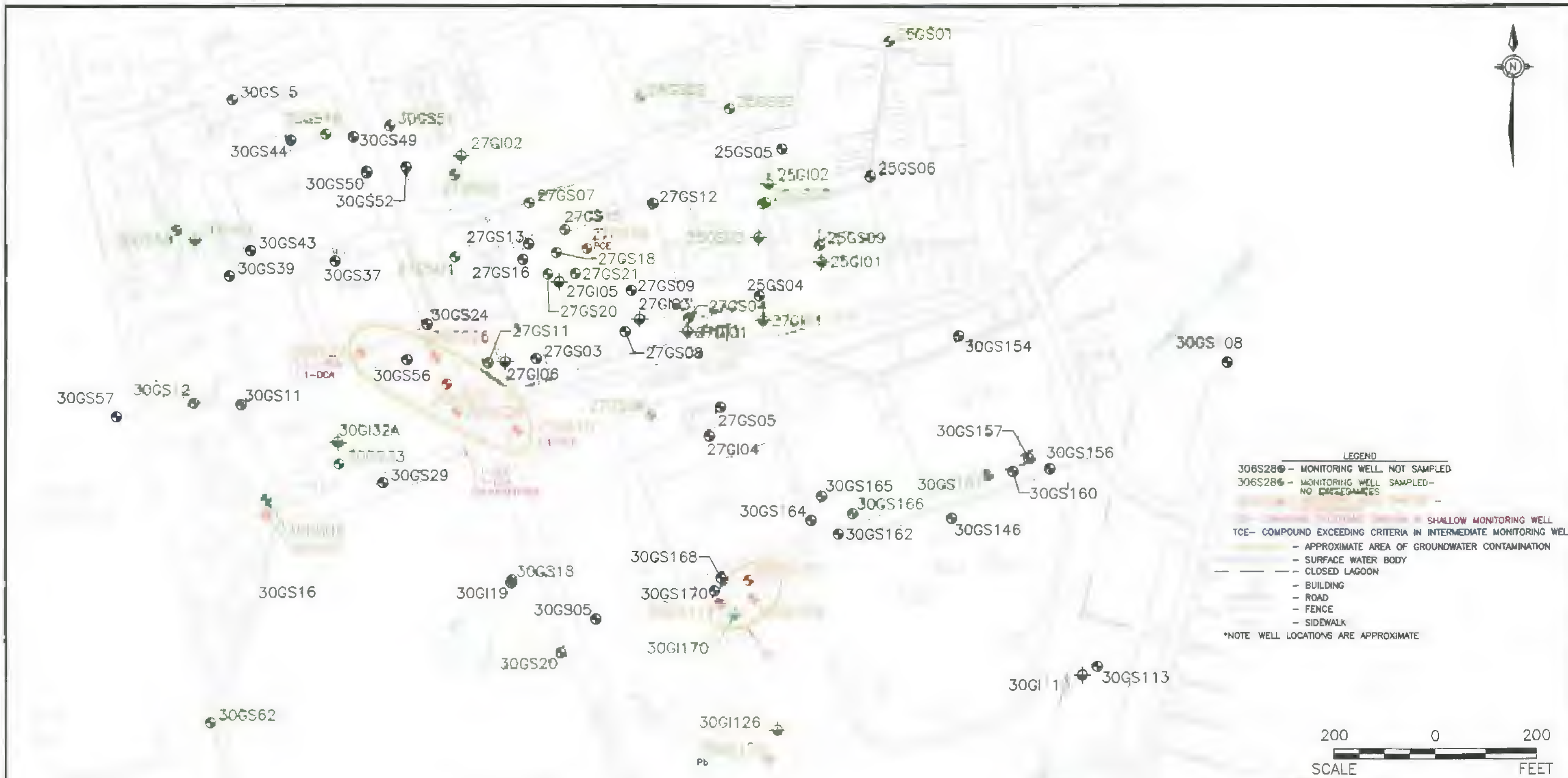
Contaminants in one of six shallow wells exceeded at least one PQG criteria; there were no intermediate well exceedances. No shallow wells had any PQG criteria exceedances when secondary metals were excluded. Site 25 wells in which samples exceeded exceeding PGQ criteria during Phase II are shown in Figure 9-8.

Table 9-2 lists the compounds exceeding the PQG criteria.

Table 9-2
Site 25 PQG Criteria Exceedances, Phases I and II

Sample ID	Parameter	Result (μg/L)	
25GS0200	Antimony	61.0	J
25GS0300	Antimony	65.4	J
25GS0400	Antimony	218.0	J
	Cadmium	54.4	
	Chromium	[illegible]	
	Lead	[illegible]	J
25GS0900	Lead	308.0	J

Notes:
J = Detection is estimated.
μg/L = Micrograms per liter
Sample IDs ending in 00 or 01 indicate Phase I sampling results; sample IDs ending in 02 or 03 indicate Phase II sampling results.
Compound-specific criteria are provided in Appendix C.



FEASIBILITY STUDY REPORT
NAS PENSACOLA OU 2

FIGURE 9-8
PHASE II
PQG CRITERIA EXCEEDANCES
SITES 25,27, AND 30

DWG DATE: 04/21/99 | DWG NAME: 0970B009

9.1.2 Site 27 ARAR Exceedances

Comparison with FPDWS and FSDWS Criteria

Phase I

Contaminants in every shallow and intermediate well exceeded at least one FPDWS and FSDWS criteria. However, only 17 out of 19 shallow wells had any FPDWS criteria exceedances when secondary metals were excluded. Contaminants exceeding criteria were primary metals (antimony, cadmium, chromium, and lead), VOCs (1,1-DCE, 1,1-DCA, total 1,2-DCE, chloroethane, tetrachloroethene, and TCE), SVOCs (2-methylnapthalene, 4-methylphenol (p-cresol), and napthalene), and pesticides/PCBs (alpha-BHC and dieldrin).

Metals and VOCs exceedances are primarily concentrated in two locations:(1) the northern portion of former Building 709 and (2) the southern portion of former building 709 extending from Site 30 to Site 25 along both sides of Farrar Road. SVOCs are also concentrated in the northern portion of the site (wells 27GS01, 27GS13, 27GS18, and 27GS19). Pesticides are randomly distributed throughout the site, diminishing the possibility of a distinguishable single source

Even when secondary metals were excluded, every intermediate well location had at least one FPDWS criteria exceedance. Contaminants exceeding criteria were primary metals (antimony, arsenic, chromium, lead, and nickel), VOCs (1,1-DCE, chloromethane, and vinyl chloride), and phenol. Metals and VOCs exceeded their criteria in intermediate wells in the same portion of the site as shallow wells contaminated with metals and VOCs.

Site 27 wells in which contaminants exceeded FPDWS criteria during Phase I are shown on Figure 9-1.

Phase II

Contaminants in nine out of 14 shallow wells and one of two intermediate wells had at least one FPDWS and FSDWS criteria exceedance. However, only six of 14 shallow wells had any FPDWS criteria exceedances when secondary metals were excluded. Contaminants that exceeded criteria were chromium, VOCs (1,1,1-TCA, 1,1-DCA, 1,1-DCE, chloroethane, tetrachloroethene, and TCE), and SVOCs (BEHP, napthalene, and pentachlorophenol).

No intermediate wells had any FPDWS criteria exceedances when secondary metals were excluded.

Since Phase I metals exceedances were not replicated in Phase II sampling, it is thought they were a result of entrained sediment in turbid Phase I samples Only one well (27GS10), within the primary area of concern had a FPDWS criteria exceedance for primary metals (chromium) during both rounds of sampling. The distribution of VOC and SVOC exceedances in Phase II was similar to Phase I's but less dispersed Based on both sampling phases, a statistically significant VOC concentration in the southwest portion of the site is likely part of a plume originating near the Building 649 complex in Site 30 and a potential area of concern in the northern part the site near wells 27GS16, 27GS18, 27GS19, and 27GS21. The northern portion of the site is also contaminated with SVOCs.

Site 27 wells exceeding FPDWS criteria during Phase II are shown on Figure 9-2. Table 9-3 lists the compounds exceeding the FPDWS criteria.

Table 9-3
Site 27 FPDWS Criteria Exceedances, Phases I and II

Sample ID	Parameter	Result (μg/L)	
27GS0201	Dieldrin	0.0095	J
	Lead	92.8	
27GI0101	Antimony	59.9	J
	Arsenic	93.6	J
	Chromium	392.0	
	Lead	84.3	J
	Nickel	110.0	
27GI0201	Benzene	25.0	
	Lead	34.9	
	Vinyl chloride	4.0	J
27GI0301	Antimony	39.2	J
27GI0401	1,1-dichloroethene	14.0	
27GI0501	Chloromethane	3.0	J
27GI0601	Chromium	119.0	
	Lead	21.1	
	Phenol	130.0	J
27GS0101	4-methylphenol (p-Cresol)	16.0	
	Antimony	61.1	J
	Chloroethane	25.0	
27GS0201	Lead	20.4	
27GS0301	Cadmium	5.1	
	Lead	122.0	J
	Trichloroethene	4.0	J
27GS0401	1,1-dichloroethene	51.0	
	Antimony	48.0	J
	Chromium	2170.0	
	Lead	128.0	J
27GS0402	Trichloroethene	7.0	
27GS0601	1,1-dichloroethane	300.0	
	Antimony	38.5	
	Chloroethane	35.0	
	Lead	32.4	
27GS0801	Antimony	43.6	J
27GS0901	1,1-dichloroethene	31.0	

Table 9-3
Site 27 FPDWS Criteria Exceedances, Phases I and II

Sample ID	Parameter	Result (μg/L)	
27GS0201	Dieldrin	0.0095	J
	Lead	92.8	
27GI0101	Antimony	59.9	J
	Arsenic	93.6	J
	Chromium	392.0	
	Lead	84.3	J
	Nickel	110.0	
27GI0201	Benzene	25.0	
	Lead	34.9	
	Vinyl chloride	4.0	J
27GI0301	Antimony	39.2	J
27GI0401	1,1-dichloroethene	14.0	J
27GI0501	Chloromethane	3.0	J
27GI0601	Chromium	119.0	
	Lead	21.1	
	Phenol	130.0	J
27GS0101	4-methylphenol (p-Cresol)	16.0	
	Antimony	61.1	J
	Chloroethane	25.0	
27GS0201	Lead	20.4	
27GS0301	Cadmium	5.1	
	Lead	122.0	J
	Trichloroethene	4.0	J
27GS0401	1,1-dichloroethene	51.0	
	Antimony	48.0	J
	Chromium	2170.0	
	Lead	128.0	J
27GS0402	Trichloroethene	7.0	
27GS0601	1,1-dichloroethane	300.0	
	Antimony	38.5	
	Chloroethane	55.0	
	Lead	32.4	
27GS0801	Antimony	43.6	J
27GS0901	1,1-dichloroethene	31.0	

Table 9-3
Site 27 FPDWS Criteria Exceedances, Phases I and II

Sample ID	Parameter	Result (μg/L)	
27GS1001	1,1-dichloroethene	10.0	
	Antimony	61.0	J
	Cadmium	19.6	
	Chromium	5810.0	
	Lead	44.8	J
27GS1002	1,1,1-trichloroethane	320.0	D
	1,1-dichloroethane	260.0	D
	1,1-dichloroethene	110.0	D
	Chloroethane	22.0	
	Chromium	309.0	
	Tetrachloroethene	9.0	
27GS1101	1,1,1-trichloroethane	300.0	
	1,1-dichloroethane	300.0	
	1,1-dichloroethene	26.0	
	Chloroethane	84.0	
	Dieldrin	0.0064	
	Lead	58.5	
	Tetrachloroethene	4.0	J
27GS1102	1,1-dichloroethane	120.0	D
	1,1-dichloroethene	12.0	J
27GS1301	1,1-dichloroethane	92.0	
	1,1-dichloroethene	13.0	
	4-methylphenol (p-Cresol)	100.0	
	Cadmium	63.6	
	Chloroethane	140.0	
	Lead	45.6	
	Pentachlorophenol	2.0	J
27GS1501	1,1-dichloroethane	110.0	
	Chloroethane	39.0	
27GS1601	Chloroethane	160.0	
27GS1801	alpha-BHC	0.0	J
	Cadmium	8.3	
	Chloroethane	33.0	J
	Lead	20.3	J
	Naphthalene	34.0	
	Tetrachloroethene	62.0	J
27GS1802	Naphthalene	49.0	

Table 9-3
Site 27 FPDWS Criteria Exceedances, Phases I and II

Sample ID	Parameter	Result (μg/L)	
27GS1901	1,1-dichloroethane	72.0	J
	1,2-dichloroethene (total)	180.0	
	2-methylnaphthalene	28.0	
	4-methylphenol (p-Cresol)	30.0	
	Chloroethane	96.0	J
	Naphthalene	110.0	
	Tetrachloroethene	61.0	J
	Trichloroethene	130.0	
27GS1902	BEHP	7.7	J
	Naphthalene	50.0	
	Pentachlorophenol	1.7	J
	Tetrachloroethene	32.0	D
	Trichloroethene	17.0	
27GS2001	Antimony	50.0	
	Chloroethane	87.0	
27GS2002	BEHP	9.3	J
27GS2101	1,1-dichloroethene	15.0	
	Chloroethane	190.0	

Notes:
J = Detection is estimated.
D = Detected concentrations was obtained from a diluted sample.
μg/L = Micrograms per liter
Sample IDs ending in 00 or 01 indicate Phase I sampling results; sample IDs ending in 02 or 03 indicate Phase II sampling results.
Compound-specific criteria are provided in Appendix C.

Comparison with Freshwater Surface Water Quality

Phase I/Phase II

Since Site 27 is not adjacent to any freshwater body, contaminants in the shallow aquifer do not threaten any nearby surface water.

Comparison with Marine Surface Water Quality

Phase I/Phase II

Since Site 27 is not adjacent to any saltwater body, contaminants in the shallow aquifer do not threaten any nearby surface water.

Comparison with Groundwater of PQG Criteria

Phase I

Contaminants in every shallow and intermediate well exceeded at least one PQG criteria. However, only seven of 19 shallow wells had PQG criteria exceedances when secondary metals were excluded. Contaminants exceeding their criteria were primary metals (antimony, cadmium, and chromium), VOCs (chloroethane, TCE, and tetrachloroethane), and 4-methylphenol (p-cresol). Metals exceedances are concentrated in the southwestern and western portions of the site (wells 27GS01, 27GS10, and 27GS13), while VOC and SVOC exceedances are primarily clustered in the northern portion of the site (wells 27GS16, 27GS18, 27GS19, and 27GS21).

Contaminants in only two of six intermediate wells exceeded at least one PQG criteria. Contaminants that exceeded criteria were benzene (27GI02) and phenol (27GI06). Neither well has a nearby associated shallow well exceedance to confirm the contamination.

Site 27 wells in which contaminants exceeded PQG criteria during Phase I are shown on Figure 9-7

Phase II

Contaminants in three of 14 shallow wells exceeded at least one PQG criteria. Only two of the shallow wells had any PQG criteria exceedances when secondary metals were excluded. Contaminants exceeding their criteria were 1,1-DCE (27GS10) and tetrachloroethane (27GS19).

No intermediate wells had any contaminants that exceeded their PQG criteria.

Since Phase I metals exceedances were not replicated in Phase II sampling, it is thought that elevated metals concentrations were a result of entrained sediment in turbid Phase I samples. Well 27GS19 is in the northern portion of the site where a suspected VOC and SVOC area of concern may exist. Well 27GS10 is in the southwestern portion of the site where a VOC contaminant plume is suspected.

Site 27 wells in which contaminants exceeded PQG criteria during Phase II are shown on Figure 9-8. Table 9-4 lists the locations and compounds exceeding the PQG criteria.

Table 9-4
Site 27 PQG Criteria Exceedances, Phases I and II

Sample ID	Parameter	Result (μg/L)	
[illegible]	Benzene	[illegible]	
27GI0601	Phenol	130.0	J
27GS0101	Antimony	61.1	J
27GS1001	Antimony	61.0	J
	Chromium	5810.0	
27GS1002	1,1-Dichloroethene	110.0	D
27GS1301	4-Methylphenol (p-Cresol)	100.0	
	Cadmium	63.6	
	Chloroethane	140.0	
27GS1601	Chloroethane	160.0	
27GS1801	Tetrachloroethene	62.0	J
27GS1901	Tetrachloroethene	61.0	J
	Trichloroethene	[illegible]	
27GS1902	Tetrachloroethene	32.0	D
27GS2101	Chloroethane	190.0	

Notes:
J = Detection is estimated.
D = Detected concentration was obtained from a diluted sample.
μg/L = Micrograms per liter
Sample IDs ending in 00 or 01 indicate Phase I sampling results; sample IDs ending in 02 or 03 indicate Phase II sampling results.
Compound-specific criteria are provided in Appendix C.

9.1.3 Site 30 ARAR Exceedances

Comparison with FPDWS and FSDWS Criteria

Phase I

Contaminants in 43 out of 51 shallow and 11 out of 12 intermediate wells exceeded at least one FPDWS and FSDWS criteria. Only 27 out of 51 shallow wells had any FPDWS criteria exceedances when secondary metals were excluded. Contaminants that exceeded their criteria were primary metals (cadmium, chromium, and lead), VOCs (1,1,1-TCA, 1,1-DCA, 1,1-DCE, 1,2-DCA, 1,2-DCE (total), benzene, chlorobenzene, chloroform, methylene chloride, tetrachloroethane, TCE, vinyl chloride, and total xylenes), SVOCs (2,4-dichlorophenol, 2-methylnapthalene, 4-methylphenol (p-cresol), BEHP (common laboratory artifact), carbazole, napthalene, and phenol), and pesticides/PCBs (heptachlor epoxide and toxaphene) Exceedances are discussed spatially below:

- **Building 649 —** Primary metals exceeded their criteria in wells 30GS22 (lead), 30GS27 (chromium), and 30GS28 (cadmium) Chlorinated VOCs (1,1-DCA 1,1-DCE, and tetrachloroethane) exceeded their criteria in wells 30GS22, 30GS26, and 30GS28. TCE also exceeded its criteria in well 30GS28. These compounds, along with VOC exceedances in the southwestern portion of Site 27, contribute to a chlorinated VOC plume that extends from Building 649 east-southeast.

- **Northern and Western Portion of Site 30 —** Lead, BTEX, and SVOCs exceeded their criteria in wells 30GS06, 30GS12. 30GS16, and 30GS57. 1,1,1-TCA, 1,2-DCE, 4-methylphenol, tetrachloroethene, and TCE exceeded their criteria in well 30GS46, in the northern portion of the site. Since no exceedances were detected in well 30GS49, which is downgradient of well 30GS46, the contamination is considered isolated.

- **Buildings 3220 and 3450** — Chlorinated VOCs (1,1,1-TCA, 1,1-DCE, and 1,1-DCA) exceeded their criteria in wells 30GS162, 30GS164, 30GS165, and 30GS166 outside the southeast corner of Building 3220. Benzene exceeded its criteria in wells 30GS170 and 30GS171, adjacent to the southwest corner of Building 3220. Additional exceedances in this area do not appear to be consistent from well to well.

- **Creek and Adjacent Sewer System** — One contaminant each exceeded FPDWS and FSDWS criteria in two nearby wells: chlorobenzene in well 30GS111 and toxaphene in well 30GS123.

Contaminants in seven of 12 intermediate wells exceeded at least one FPDWS criteria Contaminants exceeding their criteria were primary metals (cadmium and lead), VOCs (1 1 1-TCA, 1,1-DCA, 1,1-DCE, methylene chloride, TCE, and vinyl chloride), and SVOCs (1 3-dichlorobenzene, 1,4-dichlorobenzene, 2,4-dichlorophenol, bromodichloromethane, and dibromochloromethane). Contaminant exceedances in wells 30GI32A, 30GI111, 30GI164, and 30GI170 were comparable to those in nearby shallow wells.

Site 30 wells in which contaminants exceeded FPDWS criteria during Phase I sampling are shown on Figure 9-1.

Phase II

Contaminants in 14 out of 23 shallow wells and three of five intermediate wells exceeded at least one FPDWS and FSDWS criteria. Only 13 out of 23 shallow wells had any FPDWS criteria exceedances when secondary metals were excluded. Contaminants that exceeded their criteria were primary metals (antimony, cadmium, chromium, and lead), VOCs (1,1,1-TCA, 1,1-DCA, 1,1-DCE, 1,2-DCA, 1,2-DCE, benzene, chloroethane, tetrachloroethene, toluene, TCE), and SVOCs (BEHP and pentachlorophenol). Phase II exceedances are discussed spatially below:

- **Building 649** — Primary metals exceeded their criteria in wells 30GS22 (lead) and 30GS28 (cadmium and chromium). Chlorinated VOCs (1,1-DCA, 1,1-DCE, and tetrachloroethane) exceeded their criteria in wells 30GS22, 30GS26, 30GS27, and 30GS28 at significantly higher concentrations than in Phase I. Quiescent sampling may have reduced VOC volatilization during sampling. Phase I and II contaminant exceedance agreement confirms that a chlorinated VOC plume extends east-southeast from Building 649 toward Building 3220, with contaminant concentrations attenuating significantly at the southeastern edge

- **Northern and Western Portions of Site 30** — No significant pattern of contamination was evident. Isolated primary metals, VOCs (benzene), and SVOCs (pentachlorophenol) exceed FPDWS criteria in the western portion of the site Well 30GS46 has isolated VOC and SVOC exceedances.

- **Buildings 3220 and 3450** — Phase I VOC exceedances were not confirmed due to the limited number of Phase II samples collected in this area. However, a 1,1-DCE exceedance was confirmed at well 30GS172. Cadmium exceeded its criteria in wells 30GS171, 30GS172, and 30GS173, which are adjacent to the southwest corner of Building 3220. Cadmium was also detected in well 30GS126, which is downgradient of Building 3220

- **Creek and Adjacent Sewer System** — Cadmium and lead exceeded their criteria in well 30GS126. VOCs and SVOCs exceeded their criteria in intermediate well 30GI111.

Contaminants in one of five intermediate wells (30GI111) exceeded at least one FPDWS. Contaminants that exceeded their criteria were 1,3-dichlorobenzene, 1,4-dichlorobenzene, 2,4-dichlorophenol, benzene, and vinyl chloride. VOCs were detected in well 30GI111 in both sampling phases.

Site 30 wells in which contaminants exceeded FPDWS criteria during Phase II are shown on Figure 9-2. Table 9-5 lists the locations and compounds exceeding the FPDWS criteria.

Table 9-5
Site 30 FPDWS Criteria Exceedances, Phases I and II

Sample ID	Parameter	Result (µg/L)	
30GI0901	Trichloroethene	[illegible]	
30GI3201	Cadmium	7.5	
30GI6001	Bromodichloromethane	1.0	J
	Dibromochloromethane	2.0	J
30GI11101	1,3-dichlorobenzene	37.0	
	1,4-dichlorobenzene	180.0	J
	2,4-dichlorophenol	3.0	J
	Benzene	2.0	J
	Chlorobenzene	620.0	D
	Vinyl chloride	20.0	
30GI11102	1,3-dichlorobenzene	37.0	
	1,4-dichlorobenzene	140.0	D
	2,4-dichlorophenol	3.2	J
	Benzene	7.0	
	Vinyl chloride	[illegible]	
	1,1,1-trichloroethane	950.0	
	1,1-dichloroethane	320.0	
	1,1-dichloroethene	410.0	
	Lead	27.3	
	Methylene chloride	11.0	J
30GI17001	Trichloroethene	[illegible]	
30GI32A01	1,1,1-trichloroethane	300.0	
	1,1-dichloroethene	14.0	J

Table 9-5
Site 30 FPDWS Criteria Exceedances, Phases I and II

Sample ID	Parameter	Result (µg/L)	
30GS0300	Tetrachloroethene	7.0	J
30GS0600	2,4-dichlorophenol	3.0	J
	2-methylnaphthalene	35.0	
	Benzene	250.0	
	Carbazole	14.0	J
	Lead	34.8	J
	Methylene chloride	12.0	J
	Naphthalene	76.0	
30GS0602	Benzene	2.0	
30GS1200	BEHP	18000.0	J
	Naphthalene	29000.0	J
	Xylene (Total)	29000.0	
30GS1202	Pentachlorophenol	1.4	J
30GS1601	Phenol	38.0	
30GS2200	1,1,1-trichloroethane	1400.0	D
	1,1-dichloroethane	900.0	D
	1,1-dichloroethene	170.0	
	Lead	32.5	J
	Naphthalene	23.0	
	Tetrachloroethene	10.0	J
30GS2202	1,1,1-trichloroethane	2100.0	D
	1,1-dichloroethane	1400.0	D
	1,1-dichloroethene	68.0	D
	BEHP	11.0	
	Chloroethane	110.0	D
	Lead	56.2	
	Tetrachloroethene	13.0	
30GS2600	1,1-dichloroethane	160.0	
	1,1-dichloroethene	17.0	
	Tetrachloroethene	7.0	J
30GS2602	1,1,1-trichloroethane	740.0	D
	1,1-dichloroethane	2600.0	D
	1,1-dichloroethene	140.0	
	Chloroethane	180.0	D
	Tetrachloroethene	12.0	

Table 9-5
Site 30 FPDWS Criteria Exceedances, Phases I and II

Sample ID	Parameter	Result (µg/L)	
30GS2700	1,1,1-trichloroethane	1300.0	
	1,1-dichloroethene	510.0	
	Chromium	1380.0	
	Tetrachloroethene	11.0	J
30GS2702	1,1,1-trichloroethane	1700.0	D
	1,1-dichloroethane	4300.0	D
	1,1-dichloroethene	240.0	D
	1,2-dichloroethane	200.0	D
	Chloroethane	520.0	D
	Tetrachloroethene	12.0	
30GS2800	1,1,1-trichloroethane	1300.0	D
	1,1-dichloroethane	380.0	
	1,1-dichloroethene	220.0	
	1,2-dichloroethane	6.0	J
	1,2-dichloroethene (total)	210.0	
	Cadmium	7.8	
	Chromium	715.0	
	Tetrachloroethene	310.0	
	Trichloroethene	36.0	J
30GS2802	1,1,1-trichloroethane	2000.0	D
	1,1-dichloroethane	2400.0	D
	1,1-dichloroethene	130.0	D
	1,2-dichloroethane	220.0	D
	Cadmium	108.0	
	Chloroethane	580.0	D
	Chromium	418.0	
	cis-1,2-dichloroethene	120.0	D
	Tetrachloroethene	10.0	
	Trichloroethene	5.0	
30GS2900	Benzene	3.0	J
30GS4600	1,1,1-trichloroethane	220.0	
	1,2-dichloroethene (total)	220.0	
	4-methylphenol (p-Cresol)	21.0	
	Tetrachloroethene	200.0	
	Trichloroethene	4.0	J

Table 9-5
Site 30 FPDWS Criteria Exceedances, Phases I and II

Sample ID	Parameter	Result (µg/L)	
30GS4602	BEHP	9.0	J
	cis-1,2-dichloroethene	190.0	D
	Tetrachloroethene	1100.0	D
	Toluene	1100.0	D
	Trichloroethene	58.0	D
30GS5000	Trichloroethene	4.0	J
30GS5100	2,4-dichlorophenol	1.0	J
	4-methylphenol (p-Cresol)	15.0	
30GS5102	BEHP	13.0	J
30GS5900	Lead	96.0	J
30GS6200	Chloroform	80.0	
	Lead	17.0	J
30GS10302	Antimony	7.8	J
	Cadmium	5.1	J
	Lead	37.1	
30GS11101	Chlorobenzene	720.0	
30GS12301	Toxaphene	4.8	
30GS12602	Cadmium	21.8	
	Lead	236.0	
30GS15401	Vinyl chloride	110.0	
30GS15601	Heptachlor epoxide	0.029	J
	Phenol	54.0	
30GS15701	Cadmium	8.6	
30GS16001	Phenol	14.0	
30GS16201	1,1,1-trichloroethane	260.0	
	1,1-dichloroethene	100.0	
30GS16401	1,1,1-trichloroethane	290.0	D
	1,1-dichloroethene	99.0	
30GS16501	1,1-dichloroethane	76.0	
	1,1-dichloroethene	11.0	
30GS16601	1,1-dichloroethene	9.0	J

Table 9-5
Site 30 FPDWS Criteria Exceedances, Phases I and II

Sample ID	Parameter	Result (μg/L)	
30GS17001	Benzene	2.0	J
	Phenol	47.0	
30GS17101	Benzene	2.0	J
30GS17102	Cadmium	158.0	J
30GS17201	1,1-dichloroethene	10.0	J
30GS17202	1,1-dichloroethene	46.0	D
	Cadmium	2070.0	
30GS17302	Cadmium	710.0	

Notes:
J = Detection is estimated.
D = Detected concentration was obtained from a diluted sample.
μg/L = Micrograms per liter
Sample IDs ending in 00 or 01 indicate Phase I sampling results; sample IDs ending in 02 or 03 indicate Phase II sampling results.
Compound-specific criteria are provided in Appendix C.

Comparison with Freshwater Surface Water Quality

Phase I

Contaminants in 48 out of 51 shallow wells and 11 out of 12 intermediate wells exceeded at least one FSWQ criteria. However, only 14 of 27 shallow wells that border freshwater bodies had any FSWQ criteria exceedances when secondary metals were excluded. Contaminants that exceeded criteria were mercury, VOCs (1,1-DCE, benzene, and chlorobenzene), SVOCs (BEHP and phenol), and the pesticides toxaphene and heptachlor epoxide. Chlorobenzene exceeded its criterion in adjacent wells 30GS111 and 30GS123 and phenol exceeded its criteria in wells 30GS146, 30GS156, 30GS160, 30GS168, and 30GS170, which are grouped near Buildings 3220 and 3450.

Only two of five intermediate wells that border freshwater bodies had any FSWQ criteria exceedances when secondary metals were excluded. Contaminants that exceeded their criteria were 1,3-dichlorobenzene, benzene, and chlorobenzene in well 30GI111 and BEHP in well 30GI113.

Site 30 wells in which contaminants exceeded FSWQ criteria during Phase I are shown on Figure 9-3; Site 30 wells adjacent to Site 11 are shown on Figure 8-3.

Phase II

Contaminants in 14 of 23 shallow and three of five intermediate wells exceeded at least one FSWQ criteria However only five out of 12 shallow wells that border freshwater bodies had any FSWQ criteria exceedances when secondary metals were excluded. Contaminants that exceeded their criteria were chlorobenzene (30GS111), mercury (30GS126), beryllium (30GS171, 30GS172, and 30GS173). 1,1-DCE (30GS172), and endrin (30GS172)

Contaminants in only one of two intermediate wells (30GI111) that border freshwater bodies had any FSWQ exceedances when secondary metals were excluded. Contaminants exceeding their criteria were 1,3-dichlorobenzene, 1,4-dichlorobenzene, benzene, and phenol.

Site 30 wells in which contaminants exceeded their FSWQ criteria during Phase II are shown on Figure 9-4; Site 30 wells adjacent to Site 11 are on Figure 8-4.

Surface water samples from Wetland 5A/5B contained antimony (5A05), barium (5A01, 5A04, 5A05, 5A06, 5A07, and 5B02), cadmium (5A02 and 5B02), chromium (5A05 and 5B02), lead (5A02, 5A04, 5A05, 5A07, and 5B02), mercury (5B02), thallium (5A01), 1,1-DCA (5A06), 1,1-DCE (5A01), 1,2-DCE (5A06), bromodichloromethane (5A06), chloroform (5A06), dibromochloromethane (5A06), TCE (5B02), vinyl chloride (5B02), 2-chlorophenol (5B02), pyrene (5B02), and BEHP (5A05 and 5A06).

Surface water samples from Wetland 6 contained barium (0607 and 0610), lead (0607 and 0610), mercury (0610), thallium (0607), cyanide (0610), and BEHP (0610).

Wetlands 5A/5B and 6 sediment and surface water samples were compared to FSWQ exceedances for nearby wells. The comparison (shown in Table 9-6) suggests that no contaminant plume threatens the freshwater creek. In general, there was minimal connectivity between groundwater and sediment/surface water contamination. Thus, based on Site 41 sediment and surface water samples and Phase I and II groundwater sampling, Site 30 is not a primary source of wetland contamination. The Site 41 RI indicated that the primary contributor to saltwater wetlands contamination is likely current and historical storm water runoff, not groundwater infiltration.

Table 9-6
Wetland 5A/5B and 6 Sediment and Surface Water Samples

Sample Location	Nearby Wells	Common Sediment Contaminants	Common Surface Water Contaminants	Comment
5A01	30GS29	none	none	—
5A02	30GS29	none	none	—
5A03	30GS29	none	N/A	No surface water sample.
5A04	30GS16	none	none	Mercury concentration in sediment sample is 15.8% of total hazard (HQ = 4.15).
	30GS62	mercury	none	
5A05	30GS05	none	none	—
	30GS18	none	none	
	30GI19	none	none	
	30GS20	none	none	

Table 9-6
Wetland 5A/5B and 6 Sediment and Surface Water Samples

Sample Location	Nearby Wells	Common Sediment Contaminants	Common Surface Water Contaminants	Comment
5A06	30GS05	none	none	—
	30GS20	none	none	
5A07	30GS62	none	none	—
5B01	30GS05	none	N/A	No surface water sample.
	30GS20	none	N/A	
	30GS168	none	N/A	
	30GS169	none	N/A	
	30GI170	none	N/A	
	30GS170	none	N/A	
	30GS171	none	N/A	
	30GS172	none	N/A	
	30GS173	none	N/A	
5B02	30GI126	none	none	Mercury concentration in sediment sample is 1.3% of total hazard.
	30GS126	mercury	mercury	
	30GS168	none	none	
	30GS169	none	none	
	30GI170	none	TCE	
	30GS170	none	none	
	30GS171	none	none	
	30GS172	none	none	
	[illegible]	none	none	
0607	30GI111	none	none	-
	30GS111	none	none	
	30GS123	none	none	
0609	30GI112	none	N/A	No surface water sample.
	30GS113	none	N/A	

Table 9-6
Wetland 5A/5B and 6 Sediment and Surface Water Samples

Sample Location	Nearby Wells	Common Sediment Contaminants	Common Surface Water Contaminants	Comment
0610	30GS108	none	none	BEHP is a common laboratory artifact. The mercury concentration in the surface water sample exceeds all surface water criteria (Classes I to V).
	30GS146	none	BEHP	
	30GS154	none	BEHP	
	30GS155	none	BEHP	
	30GS156	none	mercury	
	30GS157	none	none	
	30GS159	none	BEHP	
	30GS160	none	none	
	30GS161	none	none	

Table 9-7 lists the locations and compounds exceeding freshwater surface water quality criteria for wells that border freshwater bodies.

Table 9-7
Site 30 Freshwater Surface Water Quality Criteria Exceedances, Phases I and II

Sample ID	Parameter	Result (µg/L)	
30GI11101	1,3-Dichlorobenzene	180.0	J
	Benzene	2.0	J
	Chlorobenzene	620.0	D
30GI11102	1,3-dichlorobenzene	140.0	D
	1,4-dichlorobenzene	140.0	D
	Benzene	7.0	
	Phenol	6.9	J
30GI11301	BEHP	2.0	J
30GS2900	Benzene	3.0	J
30GS6200	Mercury	[illegible]	J

Table 9-7
Site 30 Freshwater Surface Water Quality Criteria Exceedances, Phases I and II

Sample ID	Parameter	Result (µg/L)	
30GS10301	Phenol	7.0	J
30GS11101	Chlorobenzene	720.0	
30GS11102	Chlorobenzene	19.0	J
30GS12301	Chlorobenzene	25.0	
	Toxaphene	4.8	
30GS12602	Mercury	0.06	J
30GS14601	BEHP	1.0	J
	Phenol	8.0	J
30GS15401	BEHP	1.0	J
30GS15601	BEHP	2.0	J
	Heptachlor epoxide	0.029	J
	Phenol	54.0	
30GS15701	Mercury	0.5	
30GS16001	BEHP	1.0	J
	Phenol	14.0	
30GS16801	Phenol	8.0	J
30GS17001	Benzene	2.0	J
	Phenol	47.0	
30GS17101	Benzene	2.0	J
30GS17102	Beryllium	0.6	J
30GS17201	1,1-dichloroethene	10.0	J
30GS17202	1,1-dichloroethene	46.0	D
	Beryllium	0.4	J
	Endrin	0.008	J
30GS17302	Beryllium	0.3	J

Notes:

J = Detection is estimated.
D = Detected concentration was obtained from a diluted sample.
µg/L = Micrograms per liter
Sample IDs ending in 00 or 01 indicate Phase I sampling results; sample IDs ending in 02 or 03 indicate Phase II sampling results.
Compound-specific criteria are provided in Appendix C.

Comparison with Marine Surface Water Quality

Phase I

Contaminants in 45 of 51 shallow wells and 10 out of 12 intermediate wells exceeded at least one MSWQ criteria. However, only 1 out of 3 shallow wells that border saltwater bodies had any MSWQ criteria exceedances when secondary metals were excluded. The contaminants that exceeded their criteria in well 30GS103 were lead and phenol. The exceedances were south of the Yacht Basin mouth.

No intermediate wells bordering freshwater bodies had any MSWQ criteria exceedances when secondary metals were excluded.

Site 30 wells in which contaminants exceeded MSWQ criteria during Phase I are shown on Figure 9-5

Phase II

Contaminants in 14 of 23 shallow wells and four of five intermediate wells exceeded at least one MSWQ criteria. However, only 1 shallow well that borders a saltwater body had any MSWQ criteria exceedances when secondary metals were excluded. Only lead exceeded its MSWQ criterion in 30GS103.

No intermediate wells that border saltwater bodies had any MSWQ criteria exceedances when secondary metals were excluded.

Lead was also detected in intermediate well 11GI15 and wetland 64 sediment sample location 6401, which are both near well 30GS103. However, lead represents only 1.1% of the total hazard (HQ = 1.26) at the sediment sample location. Thus, based on Site 41 sediment samples and

Phase I and II groundwater sampling, Site 30 is not a primary source of saltwater wetland contamination. The Site 41 RI indicated that the primary contributor to saltwater wetlands contamination is likely current and historical storm water runoff, not groundwater infiltration. As discussed previously, Site 30 soil and groundwater are not considered a potential threat to adjacent saltwater water bodies.

Site 30 wells in which contaminants exceeded MSWQ criteria during Phase II are shown on Figure 9-6. Table 9-8 lists the compounds that exceeded MSWQ criteria.

Table 9-8
Site 30 Marine Surface Water Quality Exceedances, Phases I and II

Sample ID	Parameter	Result (μg/L)
30GS10301	Lead	10.2 J
	Phenol	7.0 J
30GS10302	Lead	37.1

Notes:
J = Detection is estimated.
μg/L = Micrograms per liter
Sample IDs ending in 00 or 01 indicate Phase I sampling results; sample IDs ending in 02 or 03 indicate Phase II sampling results.
Compound-specific criteria are provided in Appendix B.

Comparison with Groundwater of PQG Criteria

Phase I

Contaminants in 21 of 51 shallow wells and 10 of 12 and intermediate wells exceeded at least one PQG criteria. However, only 11 of the shallow wells had any exceedances when secondary metals were excluded. Contaminants that exceeded their criteria were chromium, VOCs (1,1-DCA, 1,1-DCE, 1,2-DCA, benzene, chloroethane, chloroform, tetrachloroethene, TCE, and vinyl chloride), SVOCs (BEHP and napthalene), and heptachlor epoxide. VOC exceedances were concentrated in the Building 649 complex area and south of Buildings 3220 and 3450. Wells 30GS46 (tetrachloroethene and TCE) and 30GS154 (vinyl chloride) had isolated exceedances.

Contaminants in three of 12 intermediate wells exceeded at least one PQG criteria. Contaminants that exceeded criteria were 1,3-dichlorobenzene and vinyl chloride (30GI111), 1,1-DCE (30GI164), and TCE (30GI170).

Site 30 wells in which contaminants exceeded PQG criteria during Phase I sampling are shown on Figure 9-7.

Phase II

Contaminants in nine of 23 shallow wells and one out of 5 intermediate wells exceeded at least one PQG criteria. However, only eight shallow wells had any PQG exceedances when secondary metals were excluded Contaminants that exceeded their criteria were primary metals (cadmium and lead) and VOCs (1,1,1-TCA, 1,1-DCA, 1,1-DCE, 1,2-DCA, and chloroethane). VOC-contaminated wells 30GS22, 30GS26, 30GS27, and 30GS28 are located in the Building 649 area. Cadmium- and lead-contaminated wells 30GS171, 30GS172, and 30GS173 are south of Building 3220. Well 30GS126 (cadmium) is adjacent to the freshwater creek south of Building 3220.

Contaminants in one of five intermediate wells (30GI111) exceeded at least one PQG criteria. Contaminants exceeding their criteria were 1,3-dichlorobenzene and vinyl chloride.

Site 30 wells in which contaminants exceeded PQG criteria during Phase II sampling are shown on Figure 9-8.

Based on both sampling phases, significant VOC contamination in the southwest portion of the site, is likely part of a plume originating near the Building 649 complex in Site 30 and a potential metals and VOC area of concern south of Buildings 3220 and 3450. Table 9-9 lists the compounds exceeding the PQG criteria.

Table 9-9
Site 30 PQG Criteria Exceedances, Phases I and II

Sample ID	Parameter	Result (μg/L)	
30GI11101	1,3-dichlorobenzene	180.0	J
	Vinyl chloride	20.0	
30GI11102	1,3-dichlorobenzene	140.0	D
	Vinyl chloride	15.0	
30GI16401	1,1-dichloroethene	410.0	
30GI17001	Trichloroethene	34.0	
30GS0600	Benzene	280.0	
30GS1200	BEHP	18000.0	J
	Naphthalene	29000.0	J
30GS2200	1,1-dichloroethane	900.0	D
	1,1-dichloroethene	170.0	
30GS2202	1,1,1-trichloroethane	2100.0	D
	1,1-dichloroethane	1400.0	D
30GS2602	1,1-dichloroethane	2600.0	D
	1,1-dichloroethene	140.0	
	Chloroethane	180.0	D
30GS2700	1,1-dichloroethene	510.0	
	Chromium	1380.0	
30GS2702	1,1-dichloroethane	4300.0	D
	1,1-dichloroethene	240.0	D
	1,2-dichloroethane	200.0	D
	Chloroethane	520.0	D
30GS2800	1,1-dichloroethene	220.0	
	Tetrachloroethene	310.0	
	Trichloroethene	36.0	J

Table 9-9
Site 30 PQG Criteria Exceedances, Phases I and II

Sample ID	Parameter	Result (μg/L)	
30GS2802	1,1-dichloroethane	2400.0	D
	1,1-dichloroethene	130.0	D
	1,2-dichloroethane	220.0	D
	Cadmium	108.0	
	Chloroethane	380.0	D
30GS4600	Tetrachloroethene	200.0	
	Tetrachloroethene	1100.0	D
	Trichloroethene	58.0	D
30GS6200	Chloroform	80.0	
30GS12602	Lead	236.0	
30GS15401	Vinyl chloride	140.0	
30GS15601	Heptachlor epoxide	0.029	J
30GS16201	1,1-dichloroethene	100.0	
30GS16401	1,1-dichloroethene	99.0	
30GS17102	Cadmium	158.0	J
30GS17202	Cadmium	2070.0	
30GS17302	Cadmium	710.0	

Notes:
J = Detection is estimated.
D = Detected concentration was obtained from a diluted sample.
μg/L = Micrograms per liter
Sample IDs ending in 00 or 01 indicate Phase I sampling results; sample IDs ending in 02 or 03 indicate Phase II sampling results.
Compound-specific criteria are provided in Appendix C.

9.2 Remedial Goals

As discussed in Section 1.3.3, background water quality exceeds FSDWS; therefore, the aquifer is considered a poor quality aquifer. Table 8-7 presents chemicals of concern and their subsequent RGs for groundwater at Site OU 2 based on poor groundwater conditions and the designation of this site as an industrial area.

As discussed in Section 8.2, groundwater RGs are GW-PQG criteria. Institutional controls are required with poor quality groundwater classification — all remedial alternatives will include costs for instituting groundwater-use restrictions and other site controls.

9.3 Groundwater Volumes

Sites 25, 27, and 30 constitute OU 2's southern portion. Groundwater typically flows east to southeast toward the freshwater creek (Wetland 6) and Chevalier Field.

These grouped sites share the following environmental issues:

- Metals — Low-flow sampling techniques used during Phase II sampling may have contributed to fewer secondary metals exceedances by significantly reducing turbidity in shallow and intermediate well samples However, even though remediation may not be required for secondary inorganics, they will impact remedial design due to operational considerations (e g. precipitation and fouling)

  Cadmium, chromium, and lead exceedances in Site 30's southeastern portion (southeastern corner of Building 649 complex) and around Buildings 3220 and 3450 occur in the same locations as suspected VOC contamination.

- **VOCs** — VOC exceedances occur in three locations: (1) a chlorinated VOC plume which extends east-southeasterly from Building 649 toward Building 3220, with contaminant concentrations attenuating significantly at the southeastern edge, (2) small areas of VOC contamination south of Buildings 3220 and 3450, and (3) isolated VOC exceedances at wells 30GS111, 30GS123, and 30GI111 along the freshwater creek.

- **SVOCs** — Exceedances are primarily clustered in Site 27's northern portion (wells 27GS16, 27GS18, 27GS19, and 27GS21). Other exceedances are isolated in the northern and western portion of Site 30 and along the freshwater creek (wells 30GS111, 30GI111, and 30GS123).

- **Pesticides/PCBs** — Pesticide exceedances are isolated, thus diminishing the possibility of a distinguishable source.

Groundwater RG exceedances occur at multiple locations, as shown on Figures 9-7 (Phase I) and 9-8 (Phase II). The southeast corner of Building 648/649/755 is characterized by a large, elliptical plume with volatiles and inorganics exceeding RGs, a smaller elliptical plume is identified southeast of Building 3220, also characterized by inorganics and VOCs. Isolated exceedances (not paired with any other well data) occur at 27GS19, 30GS154, 30GS156, and 30GS126 For these isolated exceedances, it is assumed that no continuous plume exists Impacted groundwater volumes are calculated in two ways:

- For elliptical plumes, the area of the ellipse is calculated assuming a porosity of 30% and an aquifer thickness of 40 feet (i.e., contamination is present across the entire aquifer).

- For isolated exceedances, impacted volumes are calculated assuming that contamination extends halfway to the nearest well

Impacted volumes are shown in Table 9-10

Table 9-10
Sites 25, 27, and 30 — Groundwater Volumes Exceeding RGs

Impacted Wells	Contaminants	Ellipse Size/ Nearest Well	Impacted Radius	Impacted Volume
30GS22 30GS26 30GS27 30GS28 27GS10	1,1-DCA 1,1-DCE 1,2-DCA 1,1,1-TCA PCE TCE Chloroethane Cadmium	102,000 ft^2	—	1,230,000 ft^3 9.2 million gallons
30GS162 30GS164 30GS170 30GS171 30GS172 30GS173	1,1,1-TCA 1,1-DCE 1,1-DCA TCE Cadmium	49,000 ft^2	—	594,000 ft^3 4.4 million gallons
27GS19	PCE, TCE	27GS15	25 ft	24,000 ft^3 176,000 gallons
30GS154	Vinyl chloride	30GS157	155 ft	906,000 ft^3 6.8 million gallons
30GS156	Heptachlor epoxide	30GS157	25 ft	24,000 ft^3 176,000 gallons
30GS126	Lead	30GS173	150 ft	848,000 ft^3 6.3 million gallons
30GS111	1,3-dichlorobenzene	30GS123	120 ft	543,000 ft^3 4.1 million gallons

9.4 Identification and Screening of Technologies

This section describes the initial steps toward remedy selection: identification and screening of applicable technologies. Once technologies are identified, they are reviewed for effectiveness, implementability, and cost. These criteria are discussed in Section 2.2.6. Based on this screening, technologies are either eliminated from further consideration or retained for further consideration. Alternatives for remedial action for Sites 25, 27, and 30 at OU 2 will be developed from the technologies retained.

Each treatment technology's objective, implementability, effectiveness, and cost are discussed in Table 8-9. They are consistent with technology-screening techniques presented in the NCP and USEPA guidance because they include containment, removal, disposal, and treatment options.

Technology Screening Results

Implementability, effectiveness, and cost were used to screen the technologies and to draw the following conclusions. The following technologies were all screened from further consideration.

- **Air Sparging** was screened from further consideration due to potential complications from inorganic oxidation. SVE, which is required to contain the off-gas, would likely be compromised from short circuiting due to the shallow depth to groundwater. The shallow water table limits this technology's effectiveness because it is difficult to control gases and vapor in the subsurface. The vadose zone should extend at least 10 feet below the ground surface to provide enough soil for SVE to be an effective approach to treat contaminants in soil.

- **Chemical Oxidation** was screened from further consideration for the following reasons:

  — Metal ions may cause process fouling.

  — Treatment may result in the formation of intermediates that may be more toxic than the original compounds; additional time and money may be required to determine the intermediates composition.

- Handling and storage of oxidizers may present safety problems and/or issues.

- Initial capital costs are significantly higher than those of competing technologies; however, no operations and maintenance costs are associated with this technology.

- **Electrokinetic Remediation** was screened from further consideration because the contamination is already consolidated in isolated aquifer areas. In general, electrokinetic remediation is used to consolidate groundwater contamination to increase the extraction technology's effectiveness. Furthermore, this alternative is typically more effective when the CEC and salinity are low. Because OU 2 is adjacent to a saltwater source (Yacht Basin), its salinity would likely interfere with the remedial processes Furthermore, sodium concentrations in the groundwater consistently exceed freshwater criteria across the site.

- **Enhanced Biodegradation** was screened from further consideration for the following reasons:

  - Biodegradation may be limited by the potential for background inorganics to cause microbial fouling due to the addition of oxidizing agents and pH fluctuations. Furthermore, high inorganic concentrations may be toxic to the microbial population.

  - Low contaminant concentrations will not provide a suitable substrate mass to support sustained biomass growth.

  - The wide range of contaminants in the aquifer may decrease the effectiveness of enhanced bioremediation.

- **Bioreactors** were screened from further consideration because low organic contaminant concentration in OU 2 groundwater would not be sufficient to support microbial growth. Other treatment options are more effective.

- **Carbon Adsorption** was screened from further consideration because of the potential for carbon to be inorganically fouled. Furthermore, the high cost of O&M may be prohibitive for remediation at this site.

Technologies retained for further consideration are listed below

- **Containment:** Permeable reactive barrier and groundwater extraction

- **In situ management:** Phytoremediation and monitored natural attenuation

- **Ex situ Treatment:** Air stripping with inorganics pretreatment (coagulation/precipitation, filtration, or ion exchange)

- **Offsite disposal:** Disposal to the FOTW

The NCP requires evaluation of a no-action alternative as a basis of comparison with other remedial alternatives. Because no-action may result in contaminants remaining onsite, CERCLA, as amended, requires a review and evaluation of site conditions every five years. The no action alternative will be carried through and analyzed throughout the FS process.

9.5 Development and Preliminary Evaluation of Remedial Alternatives

Following identification and screening of technologies, general response actions and process options are combined to form alternatives that address the entire site. These process options were chosen as representatives of technology types. In assembling alternatives, the NCP goal of evaluating a range of alternatives was considered. In keeping with this goal, the alternatives vary in level of effort, balance of containment versus treatment measures, cost, and remediation time frame. The following alternatives have been developed:

- **Alternative G1:** No-action
- **Alternative G2:** Monitored natural attenuation
- **Alternative G3:** Phytoremediation
- **Alternative G4:** Permeable reactive barrier
- **Alternative G5:** Groundwater extraction and Disposal to the FOTW
- **Alternative G6:** Groundwater extraction and air stripping with inorganics pretreatment
  - *Pretreatment A* Coagulation/precipitation
  - *Pretreatment B:* Membrane filtration
  - *Pretreatment C.* Ion exchange

9.5.1 Alternative G1: No-action

The NCP requires that a no-action alternative be considered as a "baseline" against which all other alternatives will be evaluated. In the no-action alternative, no remedial action will be taken. Future site use would be uncontrolled and groundwater might be used for residential purposes.

Because wastes would remain at OU 2, SARA requires that the data collected from the site be evaluated every five years. This evaluation would include spatial and temporal analysis of existing data to determine increasing, decreasing, or stationary trends in contaminant concentrations. The results of this evaluation would be used to maintain, increase, or decrease the number and types of samples and analysis required for the monitoring program. In addition, the need for remedial action would be re-evaluated every five years.

Implementability

This alternative is technically and administratively feasible. No construction, operation, or maintenance is required for no action. No technology-specific regulations are associated with this alternative.

Effectiveness

The no-action alternative does not reduce waste's toxicity, mobility, or volume in groundwater However, it is expected that current conditions represent worst-case conditions and contaminant concentrations are attenuating, thus rendering groundwater less threatening with time

Cost

NCP-required five year monitoring costs are associated with this alternative. Costs associated with the no-action alternative are presented in Table 9-11.

Table 9-11
Alternative G1: No Action Cost

Action	Quantity	Cost	Total Cost
Groundwater sampling (field work)	110 hrs	$130/hr	$14,300
Groundwater analysis	26 samples every 5 years 5 QA/QC samples per sampling event	$610/sample	$18,900[a]
Reporting/engineering	LS	20% cost	$6,600
Miscellaneous, equipment, travel, supplies, etc.	LS	25% cost	$8,300
Subtotal			**$48,100**
Present value subtotal at 6% discount over 30 years			**$117,500**
Total Cost			**$117,500[b]**

Notes:
[a] = Groundwater analytical samples include total metals, VOCs, and SVOCs.
[b] = Cost based on sampling event once every five years.
LS = Lump sum

9.5.2 Alternative G2: Monitored Natural Attenuation

Monitored natural attenuation is accepted as a remedial alternative for organic compounds dissolved in groundwater. The processes of biological degradation, advection, adsorption, dispersion, and volatilization can effectively reduce contaminant toxicity, mobility, or volume to levels that protect human heath and the environment. Monitored natural attenuation is typically used in conjunction with contaminant soil or source control actions as a groundwater remedial tool. Institutional controls would be required.

RG exceedances are monitored when they are isolated and the contaminant mass associated with the exceedance is minimal. Monitoring periodically measures contaminant concentrations and provides data that can be used to determine contaminant mobility, degradation, and dispersion rates.

Monitored natural attenuation is used when:

- Active remediation is not practicable, cost effective, or when groundwater is unlikely to be used in the foreseeable future.
- Monitored natural attenuation is expected to reduce contaminant concentrations in the groundwater to RGs in a reasonable time.
- There is little likelihood of exposure to contaminants because of site conditions.
- Natural biodegradable daughter products of the original COCs do not accumulate.

OU 2 conditions indicate that monitored natural attenuation is applicable based on an initial evaluation (e g , presence of daughter products and a trend of declining contaminant mass in the direction of groundwater flow) Groundwater use restrictions would be required; consumption of any groundwater could be prevented through appropriate application of groundwater-use restrictions. Institutional and management action could limit excess risk to current and future workers. Groundwater at OU 2 is not a practical potable water source due to ambient concentrations of iron, manganese, and other inorganics. Monitored natural attenuation requires in-depth modeling and evaluation of contaminant degradation rates and fate and transport. In addition, sampling and analysis must be conducted throughout the process to confirm that degradation is proceeding at rates consistent with cleanup objectives.

Before monitored natural attenuation can be implemented as a long-term remedy, additional site characterization is required to assess its potential for success at the site. First, data should be collected to determine whether contaminants are biodegrading. Biodegradation must be demonstrated at rates sufficient to prevent dissolved contaminants from completing exposure pathways or reaching a predetermined point of compliance at concentrations exceeding applicable regulatory standards or RGs. The monitored natural attenuation evaluation includes the following:

- Determining groundwater flow and solute-transport parameters.
- Addressing any sources and current and future exposure points.
- Comparing transport rates to attenuation rates.

If the initial screening process supports monitored natural attenuation, the site characterization must be used to build the quantitative model of solute fate and transport. Additional data may be required for the model. RI data may be used in the screening process, if applicable. The model is then used with a long-term groundwater monitoring plan to document and confirm monitored natural attenuation progress

A long-term groundwater monitoring plan is used to assess plume migration over time and to verify that monitored natural attenuation is occurring at rates sufficient to protect potential downgradient receptors. Long-term sampling frequency depends on groundwater flow velocity, the location of the point-of-compliance monitoring well(s), and other regulatory issues considered during risk management decision making. If monitored natural attenuation does not meet remedial requirements during long-term monitoring, other remedial technologies may be implemented to assist or replace it.

Implementability

This alternative is technically feasible. It must be screened during RD to determine if monitored natural attenuation can effectively reduce contaminants to concentrations that protect human heath and the environment. No construction, operation, or maintenance would be initially required.

The plume and PRG exceedances can be monitored using existing monitoring wells. However, additional monitoring wells might need to be constructed and maintained during long-term monitoring. No technology-specific regulations would apply.

This alternative is administratively feasible. OU 2 can be designated an industrial area and the use of the groundwater beneath the site can be restricted with institutional controls. If monitored natural attenuation can be shown to reduce contaminants in a reasonable time, regulatory concurrence is possible. Community acceptance would need to be obtained and would require educating the general public on the difference between no action and monitored natural attenuation.

Effectiveness

Protection of human health and the environment is accomplished by institutionally controlling exposure to site groundwater and its use This alternative requires current use of the site as an industrial area to continue for the foreseeable future; land and groundwater-use restrictions can be implemented. Should use of OU 2 change, the site might need to be re-evaluated.

Long-term effectiveness would be accomplished through the reduction of contaminant toxicity, mobility, and volume through the processes of biodegradation, advection, adsorption, dispersion, and volatilization.

Restoration of site groundwater to RGs, which might be accomplished upon completion of the monitored natural attenuation program, would reduce groundwater to below RGs for nonambient compounds. This alternative may reduce contamination below RGs, but the amount of time required for complete attenuation is not known. As discussed in the remedial elements section of this alternative, remedial design must first assess biodegradation kinetics. The presence of VOC breakdown products at OU 2 is not the only evidence that biodegradation is occurring at rates that can reach remedial goals; other evidence includes: (1) historical groundwater or soil chemistry data that demonstrates a clear and meaningful trend of declining contaminant mass and/or concentrations at appropriate monitoring or sampling points, (2) hydrogeologic or geochemical data that can be used to indirectly demonstrate the type(s) of active natural attenuation processes at the site, and (3) data from field or microcosm studies which directly demonstrate the occurrence of a particular natural attenuation process at the site and the ability to degrade the contaminants of concern. If biodegradation is demonstrated to be effective, a full monitored natural attenuation site screening and fate-and-transport modeling would need to be performed. Screening would determine if monitored natural attenuation applies to OU 2. In-depth, long-term monitoring would be used to demonstrate monitored natural attenuation effectiveness.

Monitoring of RG exceedances does not effectively reduce contaminant concentrations in groundwater. However, monitoring does provide data that can be used to measure contaminant mobility, degradation, dispersion (i e verify the effectiveness of natural attenuation)

Cost

Cost components for the monitored natural attenuation alternative would include the following (shown in Table 9-12):

- Initial monitored natural attenuation assessment
- Fate-and-transport modeling
- Groundwater sampling and analysis
- Engineering, institutional controls, and report preparation

Table 9-12
Alternative G2 : Monitored Natural Attenuation Costs

Action	Quantity	Cost	Total Cost
Initial screening			
Groundwater sampling (field work)	110 hrs	$130/hr	$14,300
Groundwater analysis	26 samples 5 QA/QC	$610/sample	$18,900*
Evaluation	260 hrs	$94/hr	$24,400
Reporting/engineering	LS	20% cost	$11,500
Misc: equipment, travel, supplies, software, etc.	LS	25% cost	$14,400
Subtotal			$83,500
Monitored natural attenuation initial startup program			
Groundwater sampling (field work)	400 hrs.	$130/hr	$52,000
Groundwater analysis	26 samples per month (3-month period) 5 QA/QC per sampling event	$610/sample	$56,700*
Institutional controls	LS	$50,000	$50,000
Reporting/engineering	LS	20% cost	$31,700
Misc: equipment, travel, supplies	LS	25% cost	$39,700
Subtotal			**$230,100**
Total capital costs			**$313,600**
Monitored natural attenuation long-term monitoring annual program			
Groundwater sampling (field work)	110 hrs.	$130/hr.	$14,300
Groundwater analysis	26 samples per year 5 QA/QC per sampling event	$610/sample	$18,900*
Evaluation	130 hrs.	$94/hr	$12,200
Reporting/engineering	LS	20% cost	$9,100
Misc. equipment, supplies, travel	LS	25% cost	$11,400
Subtotal			**$65,900**
Present value subtotal at 6% for 30 years			**$907,100**
RAC			**$100,000**
Total			**$1,320,700**

Notes:
Groundwater analytical samples include total metals, VOCs, and SVOCs.
LS = Lump sum

9.5.3 Alternative G3: Phytoremediation

Phytoremediation is an emerging technology that uses specific plant species and their associated rhizospheric microorganisms to remove, degrade, or contain chemical contaminants in soil, sediments, groundwater, surface water, and even the atmosphere. Several types of phytoremediation systems would be applicable to Sites 25, 27, and 30:

- *Rhizofiltration:* Water remediation technique involving the uptake of contaminants by plant roots. Hyperaccumulation is related to this process. Hyperaccumulation, a specific technology for the remediation of low-level, widespread heavy-metal and radionuclide contamination, is defined as the ability of a plant to uptake and store more than 2.5% of its dry weight in heavy metals To accomplish hyperaccumulation, plants are grown in contaminated soil or water and assimilate the contaminants through a process known as translocation In this process contaminants are absorbed by the root system of a plant and moved to the above ground parts of the plants/the stems and leaves/where they can easily be harvested and removed from the site

- *Phytostabilization:* Use of certain plant species to absorb and precipitate contaminants, generally metals, reducing their bioavailability, and so reducing the potential for human exposure to these contaminants. Plants used in this process often produce a large root biomass that is able to immobilize the COCs through uptake, precipitation, or reduction.

- *Phytotransformation* Use of certain plants to degrade contaminants through plant metabolism

- *Phytostimulation:* Stimulation of microbial biodegradation in the root zone. The plants provide carbonaceous material and essential nutrients through liquids released from roots and root tissue decay. In addition, oxygen released from plants increases the oxygen content in the microbially-rich rhizopheric zone.

- *Phytovolatilization:* Plants are used to evapotranspirate metals and volatile organics.

In addition, groundwater migration can be affected through the use of deep-rooted trees such as poplars to capture groundwater and retard contaminant migration. The trees take up the water and then transpire it, potentially depressing the local water table. If enough trees use the groundwater in a limited area, the water table may be depressed up to the equivalent of 3 feet of rainfall per year in semiarid areas. Through this process, contaminated groundwater that would have migrated downgradient is contained in the poplar's root zone, where it can degrade through plant processes and plant assisted bioremediation.

Laboratory and field studies would be used to determine the appropriate species of plant required to remediate the COCs In addition these studies would help in the planting scheme design including plant spacing, fertilization frequency, soil amendments, and water requirements.

Implementability

Phytoremediation is administratively feasible at Sites 25, 27, and 30. However, this alternative may not be technically feasible since the groundwater is contaminated in relatively congested, industrial areas. The more easily accessible areas are adjacent to the groundwater contamination and downgradient of it. As such, these open areas may be used to implement the phytoremedial technology

Groundwater contaminants are shallow (6 to 8 feet bgs) which contributes to phytoremedial success using poplars or other long-rooted trees Poplar roots have been demonstrated to extract groundwater from water tables as deep as 10 feet. Because there are at least eight species of Poplar indigenous to North America and their ability to form hybrids, it is expected that Poplars can be cultivated in Pensacola (Chappell, 1997).

Overall, this alternative is easy to install, maintain, and monitor. Only landscaping equipment will be required to implement this technology. Confirmatory sampling would be required to monitor its performance. No future remedial actions would be required after this alternative is completed.

Specific methods for application to contaminated sites have not been standardized, but general principles have been established The general steps followed in the design and implementation of a phytoremediation project for any of the techniques include:

- Site characterization, including determination of soil and water chemistry/conditions, climate, and contaminant distributions

- Treatability studies to determine rates of remediation and appropriate plant species, density of planting, location, etc Agricultural analyses and principles are required to complete the treatability study.

- Preliminary field testing at the site to monitor results and refine design parameters.

- Full-scale remediation

- Disposition of resulting plant material.

Effectiveness

Use of phytoremediation is currently limited to research activities and limited field testing. While several recent and on-going applications have reportedly been successful in lowering contaminant concentrations, complete full-scale applications of this innovative technology projects are scarce. Reported results show fair potential for practical applications of these techniques to achieve remedial objectives and regulatory approval; however, at least two or three more years of field tests are necessary to validate the initial, small-scale field tests.

Sites 25, 27, and 30 are sufficiently removed from the public to reduce health and safety concerns associated with groundwater remediation. Workers would be exposed to increased particulate emissions during grading and planting activities and might also have more dermal contact with potentially hazardous soil constituents. However, worker risks can be reduced by implementing dust control technologies and a site-specific health and safety plan specifying PPE, respiratory protection, etc

Phytoremediation would probably take years to satisfy remedial objectives. Table 8-12 summarizes its advantages and limitations

Cost

Costs associated with phytoremediation are presented in Table 9-13; however, current estimates costs for phytoremediation vary widely

Table 9-13
Alternative G3: Phytoremediation Costs

Action	Quantity	Cost	Total Cost
Capital Costs			
Laboratory/pilot/field studies	LS	$80,000	$80,000
Mobilization/demobilization	LS	$5,000	$5,000
Planting	4 acres	$10,000/acre	$40,000
Soil cover and amendments	4 acres	$7,500/acre	$30,000
Institutional controls	LS	$30,000	$30,000
Engineering/oversight	LS	20%	$37,000
Contingency/miscellaneous	LS	25%	$46,300
Subtotal			**$268,300**
Operations and Maintenance Costs			
Horticulture (plant health)	4 acres	$1,000/acre	$4,000
Pruning	4 acres	$1,000/acre	$4,000
Harvesting	4 acres	$2,000/acre	$8,000
Inspection	LS	$1,000	$1,000
Subtotal			**$17,000**
Present Value at 6% discount rate over 30 years			**$234,000**
Phytoremediation Long-term Monitoring Annual Program			
Groundwater sampling (field work)	110 hrs	$130/hr	$14,300
Groundwater analysis	26 samples per year 5 QA/QC per sampling event	$610/sample	$18,900*
Evaluation	130 hrs	$94/hr	$12,200
Reporting/engineering	LS	20% cost	$9,100
Misc. equipment, supplies, travel	LS	25% cost	$11,400
Subtotal			**$65,900**
Present value subtotal at 6% for 30 years			**$907,100**
RAC			**$100,000**
Total			**$1,509,400**

Notes:
Cost estimates developed from Miller, 1996 and Chappell, 1997.

LS = Lump sum

* = Groundwater analytical samples include total metals, VOCs, and SVOCs.

9.5.4 Alternative G4: Permeable Reactive Barrier

The use of permeable reactive barriers (PRB) to mitigate the spread of contaminants that have proven difficult and expensive to manage with other technologies has generated a substantial amount of interest recently as an emerging in situ technology. Reactive material, commonly zero valent iron (ZVI), is placed in the subsurface where a contaminated groundwater plume must move through it, typically under its natural gradient. The reactive matrix degrades or changes the valence state of aqueous-phase contaminants, reducing toxicity and/or mobility. The PRB is not a barrier to the water, merely a barrier to the contamination. When properly designed and implemented, PRBs can remediate contaminants to regulatory concentration goals. These systems, once installed, will have extremely low, if any, maintenance costs for at least five to 10 years. Operational costs should be minimal except for routine compliance and performance monitoring

A PRB would be used to treat the chlorinated solvent plume extending from the southeast corner of the Building 649 complex as shown in Figure 9-9 Since the area of concern is in a relatively high traffic portion of OU 2 a ZVI funnel and gate (F&G) PRB would be used to contain the plume, dehalogenate the chlorinated hydrocarbons, and precipitate some dissolved inorganic species depending on specific site geochemistry. F&G systems use impermeable walls (sheet pilings, slurry walls, etc.) as a "funnel" to direct the contaminant plume to one or more "gate(s)" containing the reactive media. Due to the impermeable funnels, the F&G PRB will impact site hydrology. The system must be designed to prevent untreated groundwater from circumventing the reactive zone by flowing around, under, or over the wall.

Wells in which contaminants exceeded PQG criteria during Phase I but not Phase II sampling would be monitored with routine quarterly sampling. These wells are listed in Table 9-14. If contamination migrated beyond these wells (i.e., detected downgradient of these wells/areas), remedial actions would be undertaken — an extraction well might be placed near each area of concern to remove the contamination In the meantime, these wells/areas will be designated for

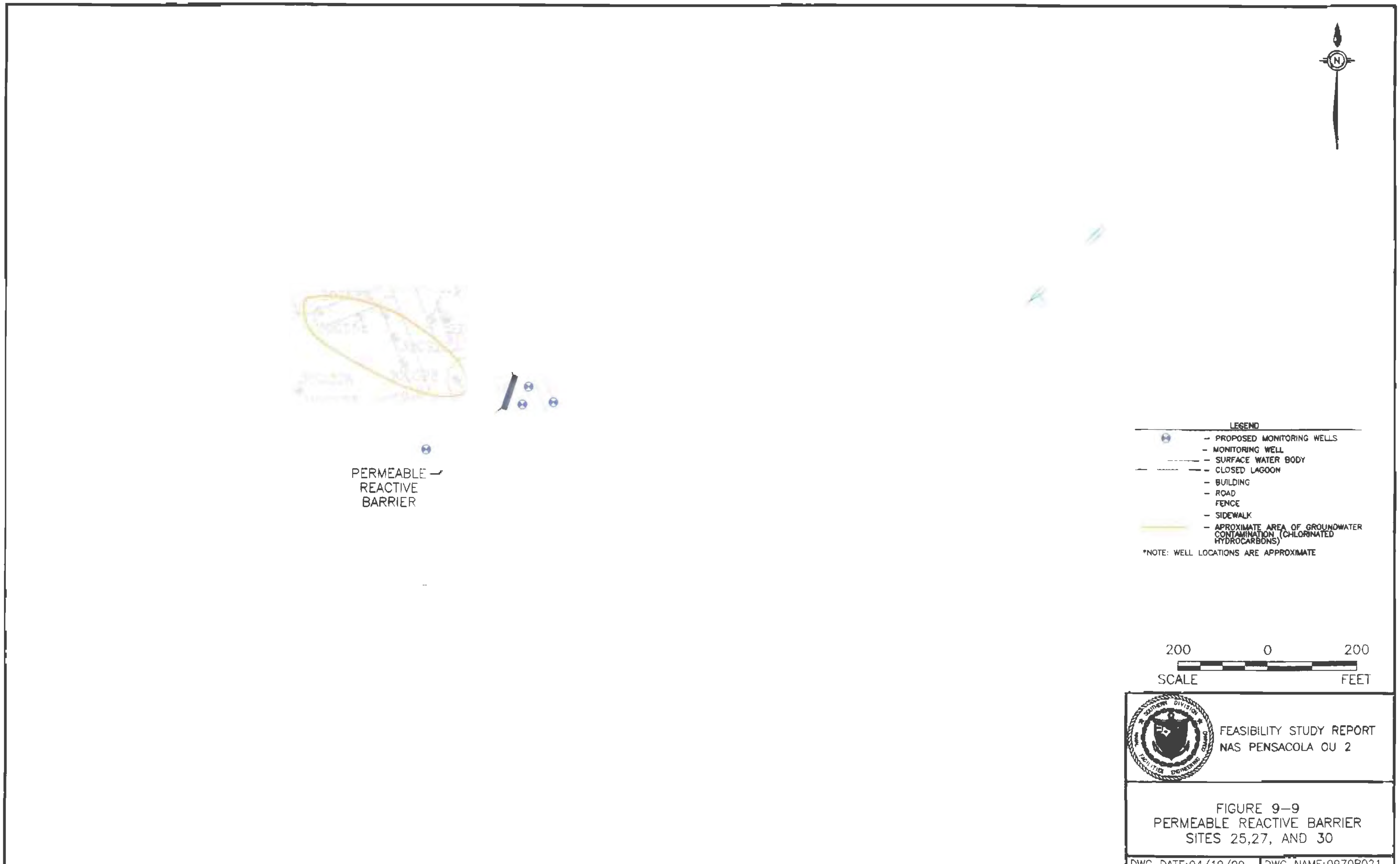


FIGURE 9–9
PERMEABLE REACTIVE BARRIER
SITES 25,27, AND 30

monitoring only based on Phase II sampling, which suggested natural attenuation of these contaminants is ongoing.

Table 9-14
Wells Requiring Routine Monitoring
(no remedial action)

Well ID	Contaminant	Comments
30GS154	vinyl chloride	Detected in Phase I; no Phase II samples. No downgradient contamination.
30GS156	heptachlor epoxide	Detected in Phase I; not detected in Phase II.
30GS162 30GS164	1,1-DCE	Detected in Phase I; not detected in Phase II.
30GS171 30GS172 30GS173	cadmium	Detected in Phase II. No downgradient contamination.
30GI111	1,3-DCB vinyl chloride	Detected in Phase I and II; however, no downgradient or adjacent surface water contamination detected.
Wells in the northern portion of Site 27	PCE TCE DCE chloroethane	Detected in Phase I (multiple wells); one well contained PCE exceeding PQG in Phase II.

Implementability

Using a PRB to remediate the Building 649 complex chlorinated hydrocarbon plume is technically and administratively implementable. A thorough understanding of site hydrogeology and geochemistry is required first to:

- Select the ideal reactive material and mix ratio with sand or other inert material.

- Determine the rate of groundwater flow through the reactive zone to establish the appropriate groundwater residence time in the reactive zone.

- Evaluate the emplacement method based on the depth to the confining layer. At Sites 25, 27, and 30, the confining layer must be accurately determined. Current estimates suggest that the confining layer is 25 to 40 feet bgs. Possible emplacement methods include: (1) excavation (confining layer: 35 to 70 feet bgs), (2) trenching machines (20 to 30 feet), (3) tremie tube (45 feet), (4) deep soil mixing, and (5) high pressure jetting. The actual emplacement method will be selected during RD.

- Select the dimensions of the reactive zone and funnel system. The treatment system must be designed to prevent water from circumventing the reactive zone. Groundwater would flow around the impermeable funnels if they do not extend far enough from the gate Moreover, groundwater can flow over the reactive zone if in situ head loss across the PRB becomes excessive. In some systems groundwater on the PRB's upgradient side of the has risen seven to 10 feet — since the water table at OU 2 is relatively shallow (6 to 8 feet where the wall would be placed), this scenario must be considered during system design. At an industrial facility in Mountainview, California, a high density polyethylene (HDPE) liner was placed atop the reactive wall to direct water through the F&M, essentially placing an impervious zone above the highly impermeable reactive zone (USEPA, 1998).

- Anticipate the impact of secondary reactions. ZVI barriers have resulted in high pH, decreased DO, and reducing conditions downgradient of the reactive zone. These temporary geochemical conditions may adversely affect certain inorganic species in the groundwater. Potentially affected compounds — arsenic, silver, and mercury — exceeded RGs during the first phase of sampling but were not detected during Phase II sampling. Downgradient monitoring wells will be used to evaluate the impact of the PRB on secondary groundwater constituents. It is anticipated that site conditions will return to normal as the groundwater flows farther from the wall. However, it is possible that the aquifer may not be able to buffer the treated groundwater. As such, the aquifer's buffering capacity must be evaluated before the barrier is designed.

- Evaluate the impact of precipitated hydroxide compounds due to site geochemistry. Significant precipitation of inorganic species can clog the wall and reduce treatment effectiveness. The appropriate reactive material mix ratio can alleviate some of these concerns.

Implementation of this alternative might temporarily disrupt operations at the facility, since the funnels would likely be installed across facility roadways. However, upon completion, the roads would be repaired and little to no further maintenance would be required Regulatory acceptance of PRBs is expected to increase as the number of site installations increases and more long-term performance data become available from existing installations

Effectiveness

The PRB alternative offers additional protection for current and future site workers when combined with the use of institutional controls and routine monitoring and sampling. Contaminated groundwater would be effectively contained and treated. This treatment alternative should reduce contaminant toxicity, mobility, the volume with the following respective mechanisms: (1) dehalogenation and degradation of the chlorinated constituents, (2) contaminant containment and treatment, and (3) contaminant elimination from the groundwater without producing any surface wastes requiring additional management. However, it is difficult to estimate the volume of water that would need to pass through the PRB and the time needed for aquifer restoration due to contaminant retardation in the aquifer. In other words, it is unknown how much of the contamination is sorbed to the aquifer matrix and how quickly it will diffuse.

New and current monitoring wells will be used to monitor the PRB effectiveness. These wells will be sampled as part of a routine monitoring program. Overall advantages and limitations associated with this technology are listed in Table 9-15.

Table 9-15
Permeable Reactive Barrier Advantages and Limitations
(USEPA, 1997)

Advantages	Limitations
In situ contaminant remediation, rather than simple migration control as with impermeable barriers.	Currently restricted to shallow plumes, approximately 50 feet or less below the ground surface.
Passive remediation — no ongoing energy input and limited maintenance following installation.	Plume must be very well characterized and delineated.
Can remediate plumes even when the source of the plume cannot be located.	Limited field data concerning longevity of wall reactivity or loss of permeability due to precipitation.
Should not alter the overall groundwater flow pattern as much as high volume pumping.	No field-tested applications have completed a removal action.
Contaminants are not brought to the surface — no potential for cross-media contamination.	Volume cost of treatment media may be exorbitant.
No disposal requirements or disposal costs for treated wastes.	Biological activity or chemical precipitation may limit the permeability of the barrier.
Avoids the mixing of contaminated and uncontaminated waters that occur with pumping.	

Cost

Costs can be separated into several categories: (1) pre-installation costs: hydrogeological and geochemical characterization of the aquifer, and laboratory, pilot, or field studies, (2) PRB installation, and (3) sampling and monitoring. These costs and their components are summarized in Table 9-16.

Table 9-16
Alternative G4: Permeable Reactive Barrier Costs

Action	Quantity	Cost	Total Cost
Capital Costs			
Pre-installation costs			
Hydrogeolgic and geochemical investigation	**LS**	**$50,000**	**$50,000**
Laboratory/pilot/field studies	LS	$50,000	$50,000
Institutional controls	**LS**	**$50,000**	**$50,000**
Installation Costs			
Funnel and gate PRB emplacement	**LS**	**$400,000**	**$400,000**
Engineering support/report preparation	LS	20% cost	$80,000
Misc. Supplies, equipment, travel	**LS**	**25% cost**	**$100,000**
Monitoring well installation	5	$2,500 / each	$12,500
Subtotal			**$742,500**
Annual Operation and Maintenance Costs			
Maintenance	**LS**	**$2,000**	**$2,000**
Subtotal			**$2,000**
Present value cost at 6% discount over 30 years			**$27,500**
Monitoring			
Sampling labor	**50 hours**	**$130.00 / hr**	**$6,500**
Laboratory	25 samples	$610.00 / sample	$15,300*
Evaluation	**40 hours**	**$94.00 / hr**	**$3,800**
Engineering support / report preparation	LS	20%	$5,100
Misc. equipment, supplies, travel, etc.	**LS**	**25%**	**$6,400**
Subtotal			**$37,100**
Present value cost at 6% discount over 30 years			**$510,700**
RAC			**$100,000**
Total			**$1,380,700**

Notes:
* = Groundwater analytical samples include total metals, VOCs, and SVOCs
LS = Lump sum

Because this is an emerging technology, costs associated with implementation can vary widely. Factors that may increase the overall cost of this alternative are:

- The need for aquifer dewatering during installation
- Disposal costs associated with groundwater and soil collected during installation
- Unusual health and safety issues/restrictions (e.g., confined space)
- Ratio of iron to sand (or other inert material) based on preliminary studies
- Hydraulic controls required during operation

9.5.5 Alternative G5: Groundwater Extraction and Disposal to the FOTW

The overall objective of the groundwater recovery system is containment of groundwater in which contaminants exceed PQG criteria and mass removal from the aquifer Exceedances are monitored to determine fluctuations in contaminant concentrations over time to ascertain contaminant degradation, mobility, and dispersion rates

Groundwater can be recovered using various well collection configurations. However, since contamination is restricted to two isolated locations based on Phase II sampling results, only one groundwater collection scenario will be evaluated: two extraction wells near wells 30GS26, 30GS27, and 30GS28 to remediate the chlorinated hydrocarbon plume, and one extraction well in the midst of wells 30GS171, 30GS172, and 30GS173. Extracted groundwater would be discharged to the FOTW through the sanitary sewer system. Extraction well locations are shown on Figure 9-10.

Wells in which contaminants exceeded PQG criteria during Phase I but not Phase II sampling would be monitored with routine quarterly sampling. These wells are listed in Table 9-14. If contamination migrated beyond these wells (i.e., detected down gradient of these wells/areas),

FEASIBILITY STUDY REPORT
NAS PENSACOLA OU 2

FIGURE 9–10
EXTRACTION WELL LOCATIONS
SITES 25,27, AND 30

DWG DATE 04/14/99 | DWG NAME 0970B022

remedial actions would be undertaken — an extraction well might be placed near each area of concern to remove the contamination. In the meantime, these wells/areas would be designated for monitoring only based on Phase II sampling, which suggests natural attenuation of these contaminants is ongoing.

Implementability

OU 2 conditions are amenable to a groundwater recovery system to capture the contaminated groundwater plume. Groundwater extraction as a remedial alternative is viable technically. Operations would be expected to be reliable and require little maintenance. Groundwater recovery is administratively feasible, as it is commonly employed as a remedial alternative. Extraction rates should be minimized to reduce the chance of saline intrusion

Discharge to the FOTW can be technically implemented A delivery and piping connection to the sanitary sewer can be constructed to discharge extracted groundwater The FOTW can handle the maximum projected flow rates Effluent concentrations of the treatment system would be required to meet FOTW discharge criteria.

This alternative does not include the use of pretreatment, which would be needed if the FOTW were unable to receive the current contaminant concentrations in the groundwater. It would be necessary to communicate with the NAS Pensacola staff to determine what pretreatment is required to complete evaluating this alternative's implementability. The remaining discussion of this alternative is based on the assumption that pretreatment is not required. Alternative G6 includes treatment

Effectiveness

The groundwater extraction and discharge alternative protects current and future site workers additionally when used with institutional controls and routine monitoring and sampling. Contaminated groundwater would be effectively contained and removed. This alternative would reduce the toxicity and mobility of the contaminated groundwater by extracting it from the aquifer. However, contaminants would be treated at the FOTW. Currently, it is difficult to estimate how much water would need to be extracted and removed to achieve adequate contaminant containment.

Cost

The costs, which are based on three extraction wells with a combined flow rate of 30 gpm, includes capital, annual operation and maintenance, and discharge expenses. The combined flow rate includes 25 gpm for the chlorinated hydrocarbon plume southeast of the Building 649 complex and 5 gpm to recover the cadmium contamination south of Building 3220. Cost analysis is based on preliminary data and modeling for feasibility purposes and cannot be considered a final design. Costs are summarized in Table 9-17.

Table 9-17
Alternative G5: Groundwater Recovery and Discharge Costs

Action	Quantity	Cost	Total Cost
Capital Costs			
Aquifer test	1	$30,000 / each	$30,000
Extraction well construction	3	$5,000 / well	$15,000
Pumps and switches	3	$3,000 / pump	$9,000
Piping and connections/excavation and backfill	LS	$20,000	$20,000
Institutional controls	LS	$50,000	$50,000
Engineering support/report preparation	LS	20% cost	$24,800
Misc. Supplies, equipment, travel	LS	25% cost	$31,000
FOTW costs	50 million gallons (5 times affected volume)	$3.00 / 1000 gal.	$150,000
Subtotal			**$329,800**

Table 9-17
Alternative G5: Groundwater Recovery and Discharge Costs

Action	Quantity	Cost	Total Cost
Annual Operation and Maintenance Costs			
Maintenance	12 months	$1,000 / month	$12,000
Electricity	10,000 kwhr	$.07 / kwhr	$700
Replacement pumps	3	$500 / pump	$1,500
Permitting/engineering support	LS	20% cost	$2,800
Misc. equipment, supplies, travel, etc.	LS	25% cost	$3,500
Subtotal			**$20,500**
Present value cost at 6% discount over 3 years			**$54,800**
Monitoring			
Sampling labor	100 hours	$ 130.00 / hr	$13,000
Laboratory	50 samples	$610.00 / sample	$30,500
Evaluation	80 hours	$94.00 / hr	$7,500
Engineering support / report preparation	LS	20%	$10,200
Misc. equipment, supplies, travel, etc.	LS	25%	$12,800
Subtotal			**$74,800**
Present value cost at 6% discount over 3 years			**$197,800**
RAC			**$100,000**
Groundwater Recovery and Discharge Total			**$682,400**

Notes:

*	=	Groundwater analytical samples include total metals, VOCs, and SVOCs.
LS	=	Lump sum
kwhr	=	Kilowatt hour

9.5.6 Alternative G6: Groundwater Extraction and Air Stripping with Inorganics Pretreatment

Under this alternative, groundwater would be extracted using the same methodology and rationale as Alternative G5. However, the extracted groundwater would be treated at a centralized location using coagulation/precipitation, membrane filtration, or ion exchange to remove inorganic contaminants and then air stripping to remove volatile organics rather than discharging directly to the FOTW. The inorganics must be treated first to avoid equipment fouling and process complications. Following air stripping, the treated groundwater would be discharged to the FOTW through the sanitary sewer system. The FOTW can handle the maximum projected flow rates The treatment system's effluent concentrations would have to meet FOTW discharge criteria

- *Pretreatment A: Coagulation/Precipitation* Removal of primary and secondary heavy metals — arsenic, cadmium, chromium, lead, iron, aluminum, and manganese — might be required The treatment technology most frequently used is coagulation, precipitation, and filtration. Such technologies are proven, effective, and implementable at OU 2 The sludge generated by this treatment technology would require dewatering (such as by filter press) to increase solid contents before disposal of the sludge and the filtrate.

- *Pretreatment B: Membrane Filtration:* Membrane filtration uses selective semipermeable materials to remove dissolved solids, such as metal salts, from the extracted groundwater. Water recovery is determined by temperature, operating pressure, and membrane surface area. This technology is proven, effective, and implementable at OU 2. The sludge generated by this treatment technology would require dewatering (such as by filter press) to increase solid contents before disposal.

- *Pretreatment C: Ion Exchange:* Ion exchange effectively treats dilute aqueous waste streams containing inorganic compounds. This technology efficiently removes iron, manganese, and many heavy metals. The groundwater is pumped through a tank containing an exchange resin. Once all the readily exchangeable ions on the exchange resin have been replaced by dissolved ions, the exhausted resin is regenerated with a solution which provides a concentrated supply of the originally bound ions. Performance is influenced by the nature of the functional group, ions available for exchange, and solution pH.

- *Primary Treatment: Air Stripping:* Air stripping is an established technology, and is effective for groundwater remediation. Volatile organics are partitioned from groundwater by increasing the surface area of the contaminated water exposed to air Types of aeration methods include packed towers, diffused aeration, tray aeration, and spray aeration Tray aeration has been preliminarily selected for OU 2. Off-gas treatment might be required for VOCs generated at the air stripper, but preliminary calculations show mass transfer rates are less than allowed by Florida Air Pollution Rules 62-210 and 62-296 for Escambia County Treated groundwater could be disposed of offsite through the FOTW or Pensacola Bay.

Implementability

OU 2 conditions are amenable to a groundwater recovery system to capture the contaminated groundwater plume. Groundwater extraction as a remedial alternative is viable technically. Operations would be expected to be reliable and require little maintenance. Groundwater recovery is administratively feasible, as it is commonly employed as a remedial alternative. Extraction rates should be minimized to reduce the chance of saline intrusion.

Groundwater treatment processes selected for this alternative are both technically and administratively feasible at OU 2. The implementation of both the air stripping for VOCs and physical-chemical treatment system for inorganics at the site is technically feasible. Specific groundwater characteristics to be determined before design and implementation are flow rate, influent concentrations, and effluent criteria.

A monitoring system should be instituted to measure process operating efficiencies of the treatment system. Various designs of physical-chemical, air stripping, and offgas treatment equipment are readily available from vendors. Offgas treatment units are available for loan or purchase basis.

The groundwater pump-and-treat system is administratively feasible. Pump-and-treat systems have historically been used to remediate contaminated aquifers. Administrative requirements would include obtaining offsite transportation permits for treatment and/or disposal of the solids generated by the treatment process Any sludge generated from the treatment process would be disposed of at an offsite landfill Solids exhibiting the toxicity characteristic would have to be disposed of offsite as a hazardous waste Air pollution standards would be met using offgas controls (such as carbon adsorption) before release of the air-stream to the environment.

Discharge to the FOTW is technically and administratively implementable. A delivery and piping connection to the sanitary sewer can be constructed to discharge extracted groundwater. Sampling treated groundwater effluent might be necessary to meet FOTW discharge requirements. If discharge to the FOTW is not possible, NPDES discharge options would be considered.

Effectiveness

The groundwater extraction, treatment, and discharge alternative protects current and future site workers additionally when used with institutional controls and sampling and monitoring. Contaminated groundwater would be effectively contained and removed. This alternative would reduce the toxicity and mobility of the contaminated groundwater by eliminating it from the aquifer. Furthermore, waste volume would be reduced using air stripping and its associated physical/chemical treatment system. Organic constituents would be transferred to the atmosphere (if the concentrations meet air regulations) or consolidated on another media (e.g., activated carbon). The inorganic compounds would be consolidated as a sludge (precipitation/coagulation and membrane filtration) or a highly concentrated liquid waste (ion exchange). Currently, it is difficult to estimate the volume of water that would need to be treated and the time required for aquifer restoration due to contaminant retardation in the aquifer.

Air stripping combined with precipitation/coagulation, membrane filtration, or ion exchange are highly effective for contaminant treatment at OU 2. The treatment process would effectively remove contaminants to concentrations below discharge limits.

Monitoring of exceedances does not effectively reduce contaminant concentrations in groundwater. However, monitoring does assess remedy performance

Cost

Cost associated with this alternative are based on groundwater extrication and discharge, and one of the following treatment options·

- G6a Coagulation/Precipitation and air Stripping
- G6b Membrane Filtration and Air Stripping
- G6c Ion Exchange and Air Stripping

The costs, which are based on two extraction wells with a combined flow rate of 30 gpm, include capital, annual operation and maintenance, and treatment expenses. Cost analysis is based on preliminary data and modeling for feasibility purposes, not a final design. Costs are summarized in Tables 9-18, 9-19 a, b, and c, and 9-20.

Table 9-18
Alternative G6: Groundwater Recovery and Discharge Costs

Action	Quantity	Cost	Total Cost
Capital Costs			
Aquifer test	[illegible]	[illegible]	[illegible]
Extraction well construction	3	$5,000 / well	$15,000
Pumps and switches	[illegible]	[illegible] / pump	[illegible]
Piping and connections/excavation and backfill	LS	$20,000	$20,000
Institutional controls	LS	[illegible]	[illegible]
Engineering support/report preparation	LS	20% cost	$24,800
Misc. supplies, equipment, travel	LS	25% cost	[illegible]
FOTW costs	50 million gallons (5 times affected volume)	$3.00 / 1000 gal.	$150,000
Subtotal			$329,800
Annual Operation and Maintenance Costs			
Maintenance	12 months	$1,000 / month	$12,000
Electricity	10,000 kwhr	$.07 / kwhr	$700
Replacement pumps	[illegible]	[illegible] / pump	[illegible]
Permitting/engineering support	LS	20% cost	$2,800
Misc. equipment, supplies, travel, etc.	LS	25% cost	[illegible]
Subtotal			$20,500
Present value cost at 6% discount over 3 years			[illegible]
Monitoring			
Sampling labor	[illegible] hours	[illegible]	[illegible]
Laboratory	50 samples	$610.00 / sample	$30,500*
Evaluation	80 hours	[illegible] / hr	[illegible]

Table 9-18
Alternative G6: Groundwater Recovery and Discharge Costs

Action	Quantity	Cost	Total Cost
Engineering support / report preparation	LS	20%	$10,200
Misc. equipment, supplies, travel, etc.	LS	25%	$12,800
Subtotal			**$74,000**
Present value cost at 6% discount over 3 years			**$197,800**
RAC			**$100,000**
Groundwater Recovery and Discharge Total			**$682,400**

Notes:

*	=	Groundwater analytical samples include total metals, VOCs, and SVOCs.
LS	=	Lump sum
kwhr	=	Kilowatt hour

Table 9-19a
Alternative G6a: Precipitation/Coagulation and
Air Stripping System Treatment Costs

Action	Quantity	Cost	Total Cost
Capital Costs			
Treatment system			
Building	LS	$262,200	$262,200
Air supply system	1	$29,900 / each	$29,900
Tanks	[illegible]	[illegible] / each	[illegible]
Pumps and accessories	LS	$81,300	$81,300
Treatment system	LS	$168,400	$168,400
Process controls	LS	$67,600	$67,600
Installation	LS	$132,000	$132,000
Engineering	LS	20%	$157,400
Contingency	LS	25%	$196,800
Subtotal			**$1,141,100**
Air stripping treatment costs			
Treatment system	LS	$46,800 / each	$46,800
Tanks	LS	$15,600 / each	$15,600
Pumps and accessories	LS	$41,900 / each	$41,900
Process controls	LS	[illegible] / each	[illegible]

Table 9-19a
Alternative G6a: Precipitation/Coagulation and Air Stripping System Treatment Costs

Action	Quantity	Cost	Total Cost
Installation	LS	$46,800 / each	$46,800
Engineering	LS	20%	$34,100
Contingency	LS	25%	$42,700
Subtotal			**$247,400**
Total capital costs			**$1,388,500**
Annual Operating Costs			
Physical/chemical process	LS	$100,000	$100,000
Air stripping process	LS	$78,000	$78,000
Subtotal			$178,000
Present value cost at 6% discount over 3 years			**$475,800**
Solid Waste Disposal Annual Costs			
Transportation	100 cy	$10 / cy	$1,000
Sludge disposal	100 cy	$225 / cy	$22,500
Engineering / oversight	LS	20%	$4,700
Contingency	LS	25%	$5,900
Subtotal			**$34,100**
Present value cost at 6% discount over 3 years			**$91,100**
Treatment system total			**$1,955,400**
Treatment system total with groundwater recovery and discharge			**$2,637,800**

Notes:
LS = Lump sum
cy = Cubic yards

Table 9-19b
Alternative G6b: Membrane Filtration and
Air Stripping System Treatment Costs

Action	Quantity	Cost	Total Cost
Capital Costs			
Treatment system			
Building	LS	$200,000	$200,000
Tanks	3	$7,500 / each	$22,500
Pumps and accessories	LS	$25,000	$25,000
Treatment system	LS	$40,000	$40,000
Process controls	LS	$25,000	$25,000
Installation	LS	$20,000	$20,000
Engineering	LS	20%	$66,500
Contingency	LS	25%	$83,100
Subtotal			**$482,100**
Air stripping treatment costs			
Treatment system	LS	$46,800 / each	$46,800
Tanks	LS	$15,600 / each	$15,600
Pumps and accessories	LS	$41,900 / each	$41,900
Process controls	LS	$19,500 / each	$19,500
Installation	LS	$46,800 / each	$46,800
Engineering	LS	20%	$34,100
Contingency	LS	25%	$42,700
Subtotal			**$247,400**
Total			**$729,500**
Annual Operating Costs			
Physical/chemical process	LS	$70,000	$70,000
Air stripping process	LS	$78,000	$78,000
Subtotal			**$148,000**
Present value cost at 6% discount over 3 years			**$422,300**
Solid Waste Disposal Annual Costs			
Transportation	100 cy	$10 / cy	$1,000
Sludge disposal	100 cy	$225 / cy	$22,500

Table 9-19b
Alternative G6b: Membrane Filtration and Air Stripping System Treatment Costs

Action	Quantity	Cost	Total Cost
Engineering / oversight	LS	20%	$4,700
Contingency	LS	25%	$5,900
Subtotal			$34,100
Present value cost at 6% discount over 3 years			**$91,100**
Treatment system total			**$1,342,900**
Treatment system total with groundwater recovery and discharge			**$1,925,300**

Notes:
LS = Lump sum
cy = Cubic yards

Table 9-19c
Alternative G6c: Ion Exchange and Air Stripping System Treatment Costs

Action	Quantity	Cost	Total Cost
Capital Costs			
Treatment system			
Building	LS	$200,000	$200,000
Tanks	3	$7,500 / each	$22,500
Pumps and accessories	LS	$25,000	$25,000
Treatment system	LS	$60,000	$60,000
Process controls	LS	$25,000	$25,000
Installation	LS	$60,000	$60,000
Engineering	LS	20%	$78,500
Contingency	LS	25%	$98,100
Subtotal			**$569,100**
Air Stripping Treatment Costs			
Treatment system	LS	$46,800 / each	$46,800
Tanks	LS	$15,600 / each	$15,600
Pumps and accessories	LS	$41,900 / each	$41,900
Process controls	LS	$19,500 / each	$19,500

Table 9-19c
Alternative G6c: Ion Exchange and
Air Stripping System Treatment Costs

Action	Quantity	Cost	Total Cost
Installation	LS	$46,800 / each	$46,800
Engineering	LS	20%	$34,100
Contingency	LS	25%	$42,700
Subtotal			**$247,400**
Total			**$816,500**
Annual Operating Costs			
Physical/chemical process	LS	$150,000	$150,000
Air stripping process	LS	$78,000	$78,000
Subtotal			**$228,000**
Present value cost at 6% discount over 3 years			**$609,400**
Disposal of Liquid Waste at Treatment Facility Annual Costs			
Treated water disposal	50,000 gallons	$1.00 / gal.	$50,000
Engineering / oversight	LS	20%	$10,000
Contingency	LS	25%	$12,500
Subtotal			**$72,500**
Present value cost at 6% discount over 3 years			**$193,800**
Treatment system total			**$1,619,700**
Treatment system total with groundwater recovery and discharge			**$2,302,100**

Notes:
LS = Lump sum
gal = Gallons

Table 9-20
Alternative G6: Groundwater Extraction and Treatment Cost Summary

Treatment Method	Extraction and Discharge	Treatment System	Air Stripping Treatment	PW O&M Annual	PW Disposal	Total
Air Stripping with Coagulation/ Precipitation	$682,400	$1,141,100	$247,400	$475,800	$91,100	$2,637,800
Air Stripping with Membrane Filtration	$682,400	$482,100	$247,400	$422,300	$91,100	$1,925,300
Air Stripping with Ion Exchange	$682,400	$569,100	$247,400	$609,400	$193,800	$2,302,500

Notes:
PW = Present worth
O&M = Operations and maintenance

9.6 Detailed Development and Evaluation of Remedial Alternatives

The following sections analyze the groundwater alternatives presented in Section 9.5. Each alternative is evaluated according to the criteria discussed in Section 2.4. Criteria have been divided into three categories — threshold, balancing, and modifying.

9.6.1 Alternative G1: No Action

The no-action alternative for OU 2 involves no active remedial effort. No actions would be taken to contain, remove, or treat groundwater contamination. Groundwater would remain in place to attenuate according to biotic, abiotic, dilution, dispersion and other natural processes. No engineering or institutional controls would be constructed. The no-action alternative provides a baseline against which other alternatives are compared.

Threshold Criteria

The alternatives must meet two threshold criteria to be considered in the FS: overall protection of human health and the environment and compliance with ARARs

Overall Protection of Human Health and the Environment

The no-action alternative provides no additional protection of human health and the environment. Groundwater concentrations at OU 2 exceed RGs. Under the no-action scenario, these exceedances would remain; it is assumed that current groundwater contamination is "worst case" and attenuating. The surficial/sand-and-gravel aquifer is not a potable water source. As discussed previously, the main producing zone is the primary source of potable water.

The no-action alternative does not afford any long-term effectiveness and permanence under an industrial scenario beyond natural degradation of constituents. No short-term impacts are associated with this alternative, which does not reduce the mobility or volume of contaminants at OU 2 but rather allows contaminant's natural attenuation to be monitored every five years. This alternative does not comply with chemical-specific ARARs and TBC criteria because groundwater exceeding RGs could theoretically be consumed under the uncontrolled use scenario. However, groundwater consumption is not likely, as previously mentioned.

Compliance with ARARs

Alternative G1 does not comply with the chemical-specific ARARs developed in Section 9.1. Groundwater in which contaminants exceed RGs would remain. Florida Proposed Rule 62-777 is a potential ARAR for OU 2. No location- or action-specific ARARs are triggered by the no-action alternative.

Balancing Criteria

The primary balancing criteria are the technical criteria on which the detailed analysis is based.

Long-term Effectiveness and Permanence

Degradation of site contaminants is left to natural attenuation processes in this alternative, and the long-term effectiveness of the no-action alternative is minimal. Current contaminant concentrations would attenuate slowly Groundwater volume and concentrations would remain unchanged, except for intrinsic attenuation. The no-action alternative does not reduce the magnitude of residual risk and provides no means for monitoring. This alternative lacks treatment actions that would provide permanence

Any controls which are currently in place at the site - which include military security and limited site access and use - would remain. Due to the abundant supply of high quality water in the deeper main producing zone, groundwater from the surficial zone is not used as a potable water source in southern Escambia County, nor is it expected to be used for that purpose in the future.

Reduction of Toxicity, Mobility, or Volume Through Treatment

The no-action alternative would not reduce the mobility or volume of groundwater contaminants at OU 2. Toxicity may be reduced slowly through natural attenuation. Contaminants would remain in place onsite; groundwater would not be treated during remedial actions. However, intrinsic remediation processes (either biotic or abiotic degradation) would continue and are considered irreversible. Contaminated groundwater would migrate according to current transport dynamics.

Short-term Effectiveness

Short-term effectiveness assesses the effects of an alternative on human health and the environment while the remedial alternative is being implemented. No implementation concerns are associated with the no-action alternative. No risk is posed to the community, workers, or the environment during implementation. This alternative may be implemented immediately and continue indefinitely. There are no implementation risks associated with Alternative G1.

Implementability

The no-action alternative is technically feasible and easily implemented. No construction, operation or reliability issues are associated with this alternative. Current access controls including military security and limited access to personnel — have historically been reliable No administrative coordination is required for implementation of the no-action alternative, which would not require offsite services, materials, specialists, or innovative technologies.

Cost

Costs associated with the no-action alternative include groundwater monitoring and report preparation every five years for 30 years. Each sampling and reporting event is estimated at $48,100, with a present worth for the 30-year period of $117,500.

Modifying Criteria

The modifying criteria are assessed formally after the public-comment period. However, the criteria are factored into the identification of the preferred alternative as far as they are known.

State/Support Agency Acceptance

FDEP and the USEPA are involved in the partnering team process and will both have the opportunity to review and comment on this proposed plan.

Community Acceptance

Community acceptance for the no-action alternative would be established after the FS public comment period.

9.6.2 Alternative G2: Monitored Natural Attenuation

Under this alternative, contaminated groundwater is left in place. The monitored natural attenuation alternative includes initial biodegradation assessment and fate-and-transport modeling to predict expected contaminant concentrations over time Additional groundwater sampling would be required in support of this modeling. A long-term groundwater monitoring program would be implemented to assess the progress of monitored natural attenuation and to ensure that human health is protected Institutional controls would be implemented with land-use restrictions that limit land to industrial use, and restrict groundwater use beneath and downgradient of the site

Threshold Criteria

Overall Protection of Human Health and the Environment

Under an industrial scenario, monitored natural attenuation addresses the long-term effectiveness and permanence criterion by preventing exposure to the contaminant source. Protection of human health is accomplished by restrictions on groundwater use and attenuation of contaminant concentrations over time. No short-term impacts would be associated with this alternative. This alternative would not comply with chemical-specific ARARs. This alternative would not be implemented if initial modeling and screening determined that RGs or protection of human health are not met.

As previously discussed, no threats to Bayou Grande have been identified. Protection of the environment and Bayou Grande could be further monitored through monitored natural attenuation. Monitoring would help protect the Bayou Grande and the environment.

Compliance with ARARs

The monitored natural attenuation alternative is intended to comply with the chemical-specific groundwater ARARs. Modeling and groundwater sampling is intended to document degradation of contaminants over time. Florida Proposed Rule 62-777 is a potential ARAR for OU 2.

No location or action-specific ARARs would be triggered by groundwater Alternative G2.

Balancing Criteria

Long-term Effectiveness and Permanence

The monitored natural attenuation alternative eliminates residual risk to site workers by managing OU 2 as an industrial area and preventing groundwater from being used as a potable source through institutional controls. Groundwater modeling may show that monitored natural attenuation can reduce contaminants to RGs over time through natural biotic and abiotic attenuation processes. However, contaminant concentrations would likely attenuate slowly; therefore, long-term effectiveness would be minimal. The consumption of contaminated groundwater would be controlled institutionally and groundwater would be monitored until remedial goals are met.

Any controls currently in place onsite — including military security and limited access to the site — would remain. These controls are considered reliable for protecting human health, given the current and projected land use onsite

Reduction of Toxicity, Mobility, or Volume Through Treatment

Monitored natural attenuation does not reduce the mobility or volume through treatment. Toxicity is reduced slowly through monitored natural attenuation. However, toxicity may be increased due to incomplete degradation to more toxic products. Contaminants would remain in place onsite; groundwater is not treated during remedial actions. However, intrinsic remediation processes (either biotic or abiotic degradation) would continue and are considered irreversible. Contaminated groundwater would migrate according to current transport dynamics.

Short-term Effectiveness

No implementation concerns are associated with monitored natural attenuation The community is protected through groundwater restrictions and institutional controls. Workers are protected by groundwater restrictions, equipment, and training. This alternative could be executed as soon as land-use restrictions and groundwater restrictions are in place. No implementation risks are associated with Alternative G2.

Sampling wastes should be managed in a manner that reduces contact with the environment. Wastewater could be stored in 55-gallon drums and disposed of appropriately. RI waste management practices could be continued for this alternative.

Implementability

Monitored natural attenuation is technically feasible and easily implemented. Monitoring and modeling intrinsic groundwater remediation is the essential component of monitored natural attenuation. Implementation of the initial screening process is both technically and administratively feasible. While monitored natural attenuation is reliable (except when degradation results in more toxic products), screening and modeling can determine if monitored natural attenuation can reduce contaminants to RGs in a reasonable time (less than five years). No construction, operation, or maintenance issues are initially involved with this alternative. Current access controls – including military security and limited personnel access – have been reliable in the past. No administrative coordination would be required to implement the monitored natural attenuation alternative. Monitored natural attenuation would not require offsite treatment services, materials, or innovative technologies.

Cost

Cost components for the monitored natural attenuation alternative include the following:

- Initial monitored natural attenuation assessment
- Fate-and-transport modeling
- Groundwater sampling and analysis
- Engineering, institutional controls, and report compilation

Costs associated with monitored natural attenuation are detailed in Section 9 5.2. Capital costs for Alternative G2 initial screening and startup — including direct, indirect and incidentals — are approximately $304,200. Annual operating and maintenance costs for monitored natural attenuation long-term monitoring are $65,900. Assuming a 25% contingency and RAC costs, the total present value for Alternative G2 is $993,300 (assuming a 6% discount rate over 30 years).

Modifying Criteria

State/Support Agency Acceptance

FDEP and the USEPA are involved in the partnering team process and will both have the opportunity to review and comment on this FS.

Community Acceptance

Community acceptance for Alternative G2 would be established after the public-comment period for the FS. Education of the public on the difference between monitored natural attenuation and no action might be required, if monitored natural attenuation is selected as the remedial alternative. This criterion is generally not completed until after public comments on the RI/FS report and the proposed plan are received.

9.6.3 Alternative G3: Phytoremediation

In this alternative, phytoremediation would include research, bench and pilot scale feasibility testing, and planting and monitoring over approximately four acres. Institutional controls would be required to prevent domestic use since PQG criteria are the site RGs.

Threshold Criteria

Overall Protection of Human Health and the Environment

Phytoremediation protects human health and the environment by slowly removing, transforming, or immobilizing groundwater contaminants This alternative, coupled with appropriate institutional controls would eliminate risk to future site workers and the environment and drastically reduce the potential for continued contaminant migration

Short-term risks from inhalation and dermal contact during implementation would be minimal and could be controlled using common engineering techniques and appropriate PPE. This alternative would comply with applicable waste management standards and chemical-specific regulations.

Phytoremediation is still in the early stages of development. As such, long-term reliability and effectiveness are relatively unknown. However. substantial research is underway and results are promising.

Finally, public acceptance of phytoremediation can be very high, in part because of the park-like aesthetic. which includes bird and wildlife habitats

Compliance with ARARs

Phytoremediation is intended to comply with the chemical-specific ARARs developed in Section 9.1. ARARs that identify alternative cleanup target levels based on poor quality groundwater include Florida Rules 62-770, 62-781, and 62-785. Phytoremediation is the one of the least aggressive remedial technology under consideration and will likely require years to attain proposed cleanup standards. Wetland mitigation ARARs may be triggered since remedial actions would be implemented adjacent to the Bayou Grande. These location specific ARARs include the following:

- Floodplain requirements as outlined in the *National Environmental Policy Act* (40 CFR Part 6, Appendix A)

- Requirements for wetland endangered species as outlined in the *Endangered Species Act* (50 CFR Part 402 and Part 200)

No action-specific ARARs are triggered by groundwater Alternative G3.

Balancing Criteria

Short-term Effectiveness

The phytoremediation operation would be sufficiently removed from the public to reduce health and safety concerns associated with groundwater remediation. The community is protected through groundwater restrictions and institutional controls. Workers are protected by groundwater restrictions, equipment, and training. Workers may be exposed to increased particulate emissions during planting and grading activities and might also have more dermal contact with hazardous constituents. However, worker risks can be reduced by implementing dust control technologies and a site-specific health and safety plan specifying PPE, respiratory protection, etc.

Long-term Effectiveness and Permanence

Use of phytoremediation is currently limited to research activities and limited field testing. While several recent and on-going applications have reportedly been successful in lowering contaminant concentrations, complete full-scale applications of this innovative technology projects are scarce. Reported results show some potential for practical applications of these techniques to achieve remedial objectives and regulatory approval; however, at least two or three more years of field tests are necessary to validate the initial, small-scale field tests.

The consumption of contaminated groundwater would be controlled institutionally and groundwater would be monitored until remedial goals are met. Controls currently in place at the site – which include military security and limited site access and use – would remain. Due to the abundant supply of high quality water in the deeper main producing zone, groundwater from the surficial zone is not used as a potable water source in southern Escambia County, nor is it expected to be in the future The base receives its potable water from Corry Station, which is approximately three miles away

Reduction of Toxicity, Mobility, or Volume Through Treatment

This alternative would provide effective toxicity, mobility, or volume reduction by slowly removing, transforming, or immobilizing groundwater contaminants. Current site conditions are amenable to phytoremediation. However, since phytoremediation is an emerging technology, its effectiveness at this site is not known. This alternative may generate more toxic treatment residuals. Furthermore, the trees or plants may require periodic harvesting, which may trigger additional solid or hazardous waste considerations.

Implementability

Phytoremediation is technically and administratively feasible at Sites 25, 27, and 30. Areas to be remediated are readily accessible. The groundwater contaminants are shallow (6 to 8 feet bgs) which contributes to phytoremedial success Overall, this alternative is easy to install, maintain, and monitor. Only landscaping equipment would be required to implement this technology. Confirmatory sampling would be required to monitor its performance. No future remedial actions would be required after this alternative is completed. Institutional controls would be required.

Cost

Costs associated with this alternative are detailed in Section 9.5.3. Capital costs for phytoremediation, which include laboratory/pilot/field studies, planting and soil amendments, institutional controls, and indirect costs, are $268,300. Annual operating and maintenance costs for this alternative are $8,500. Long-term monitoring's annual costs are $65,900. Assuming a 25% contingency and RAC costs, the total present value for Alternative G3 is $1,092,400 (assuming a 6% discount rate over 30 years).

Modifying Criteria

State/Support Agency Acceptance

FDEP and the USEPA are involved in the partnering team process and will both have the opportunity to review and comment on this FS.

Community Acceptance

Community acceptance for the no-action alternative would be established after the public-comment period.

9.6.4 Alternative G4: Permeable Reactive Barrier

This alternative would use a PRB to contain and treat the Building 649 complex chlorinated hydrocarbon plume. Mass removal from this area of concern would eliminate a potential source of downgradient contamination.

Other areas or wells in which contaminants exceeded PQG criteria during Phase I and Phase II would be monitored using a routine sampling program. If contamination migrated beyond these wells (i.e., was detected downgradient of these wells/areas), remedial actions would be undertaken — an extraction well might be placed near each area of concern to remove the contamination. In the meantime, these wells/areas would be delegated for monitoring only based on Phase II sampling, which suggests natural attenuation of these contaminants.

Threshold Criteria

Overall Protection of Human Health and the Environment

The PRB alternative protects current and future site workers additionally when used with institutional controls and routine monitoring and sampling. Contaminated groundwater would be effectively contained and treated. This treatment alternative should reduce contaminant toxicity, the mobility, and the volume with the following respective mechanisms: (1) dehalogenation and degradation of the chlorinated constituents, (2) contaminant containment and treatment, and (3) contaminant elimination from the groundwater without producing an surface wastes requiring additional management. However, it is difficult to estimate the volume of water that would need to pass through the PRB and the time needed for aquifer restoration due to contaminant retardation in the aquifer. In other words, it is unknown how much of the contamination is sorbed to the aquifer matrix and how quickly it will diffuse.

New and current monitoring wells would be used to monitor PRB effectiveness. These wells will be sampled as part of routine monitoring which also monitors the impact of residual site contamination that will not receive active treatment under this scenario. Isolated contamination (primarily detected in Phase I sampling only) would be monitored to ensure that threats to human health and the environment do not persist.

Compliance with ARARs

The PRB complies with the chemical-specific ARARs developed in Section 9.1. ARARs that identify alternative cleanup target levels based on poor quality groundwater include Florida Rules 62-770, 62-781, and 62-785. Contaminated groundwater would be contained and treated by the PRB, thereby reducing groundwater quantities in which PQG criteria are exceeded. In situ treatment of groundwater in Sites 25, 27, and 30 is intended to reduce the contaminant mass in the aquifer and contain groundwater areas of concern.

Florida Proposed Rule 62-777 is a potential ARAR for OU 2. No location or action-specific ARARs would be triggered by groundwater Alternative G4.

Balancing Criteria

Long-term Effectiveness and Permanence

The PRB alternative, which would treat contaminated groundwater in situ, would eliminate contaminants exceeding RGs from the chlorinated hydrocarbon plume in Site 30. Remaining isolated groundwater contamination would be monitored to ensure that it would not threaten human health under an industrial scenario Institutional controls would effectively control future land use.

Using ZVI PRBs to remediate chlorinated hydrocarbon groundwater plumes is an effective option. However, currently operated barriers have not been applied long enough to gauge their long-term effectiveness.

Reduction of Toxicity, Mobility, or Volume Through Treatment

This alternative is a mass removal/containment alternative and therefore meets the preference for treatment. Groundwater treatment at Sites 25, 27, and 30 would reduce groundwater toxicity and contaminant volume. In situ groundwater containment and treatment effectively eliminates contaminant migration. This alternative would reduce mobility and volume through mass removal.

Isolated residual contamination would be monitored and gradually affected by intrinsic attenuation. Toxicity is reduced slowly through natural attenuation. Contaminants would remain in place onsite; groundwater would not be treated. However, intrinsic remediation processes (biotic or abiotic degradation) would continue and are considered irreversible. Contaminated groundwater would migrate according to current transport dynamics. Based on Phase I and II sampling results, residual contamination has already begun to naturally attenuate. The data have also demonstrated that the contamination is not migrating.

Short-term Effectiveness

Adverse impacts to the surrounding environment are not anticipated during PRB system construction. Workers should be trained according to OSHA standards as required by 29 CFR 1910 120 to protect and mitigate risks during remedial construction. Field personnel contact with site contaminants would be minimal during construction (impermeable and permeable barrier installation and site grading). Worker protection could be managed through use of appropriate PPE Compliance with RGs can be determined by monitoring site wells. System performance and mass removal can be evaluated by downgradient monitoring. Alternative G4 would be compatible with any additional remedial actions, if required.

Implementability

Using a PRB to remediate the chlorinated hydrocarbon plume extending from the southeast corner of the Building 649 complex is technically and administratively implementable. A thorough understanding of site hydrogeology and geochemistry is required to: (1) select the ideal reactive material and mix ratio with sand or other inert material, (2) determine how fast groundwater flow through the reactive zone to establish the appropriate groundwater residence time in the reactive zone, (3) evaluate the emplacement method based on the depth to the confining layer, (4) select the dimensions of the reactive zone and funnel system, (5) anticipate the impact of secondary reactions, and (6) evaluate the impact of precipitated hydroxide compounds due to site geochemistry.

Implementation of this alternative might temporarily disrupt facility operations, since the funnels would likely be installed across facility roadways. However, when installation is complete, the roads would be repaired and little or no further maintenance would be required. Regulatory acceptance of PRBs is expected to increase as the number of site installations increases and more long-term performance data become available from existing installations.

Cost

Direct and indirect costs associated with Alternative G4 are $742,500. Annual operation and maintenance costs are expected to be $21 400 (including groundwater monitoring). The total present value of Alternative G4. including implementing institutional controls and the costs for the remedial action contractor is estimated to be $1,145,000 (assuming a 6% discount rate over 30 years)

Modifying Criteria

State/Support Agency Acceptance

FDEP and the USEPA will have the opportunity to review and comment on this FS.

Community Acceptance

These criteria are generally not completed until after public comments on the RI/FS report and the proposed plan are received.

9.6.5 Alternative G5: Groundwater Extraction and Disposal to the FOTW

This alternative involves recovering groundwater by well extraction, then discharging it to the FOTW. Mass removal from the shallow aquifer in Sites 25, 27, and 30 would protect downgradient receptors. Alternative G5 would contain two areas of concern using two proposed recovery wells near wells 30GS26, 30GS27, and 30GS28 to remediate the chlorinated hydrocarbon plume, and one extraction well in the midst of wells 30GS171, 30GS172, and 30GS173. Extracted groundwater would be discharged to the FOTW through the sanitary sewer system.

Threshold Criteria

Overall Protection of Human Health and the Environment

Human health is protected by containing groundwater in which contaminants exceed PQG criteria, removing mass thus preventing contaminant migration beyond the source area in contaminated zones.

Extracted groundwater would discharge to the FOTW Institutional controls would limit groundwater use

Wells in which contaminants exceeded PQG criteria during Phase I but not Phase II sampling and well 30GI111, which exhibited isolated exceedances during both phases of sampling, would be monitored with routine quarterly sampling. If contamination persisted beyond these wells (i e., was detected downgradient of these wells/areas), remedial actions would be undertaken — an extraction well would be placed near each area of concern to remove the contamination. In the meantime, these wells/areas would be monitored only.

Compliance with ARARs

Groundwater extraction complies with the chemical-specific ARARs developed in Section 9.1. Florida Proposed Rule 62-777 is also a potential ARAR for OU 2. ARARs that identify alternative cleanup target levels based on poor quality groundwater include Florida Rules 62-770, 62-781, and 62-785. The contaminated groundwater would be captured by extraction wells, thereby removing groundwater in which contaminants exceeded PQG criteria. Removal of groundwater from Sites 25, 27, and 30 is intended to reduce the mass of contaminants in the aquifer and contain the groundwater areas of concern. Location- and action-specific ARARs include the following:

- Floodplain requirements as outlined in the *National Environmental Policy Act* (40 CFR Part 6, Appendix A).

- Requirements for wetland endangered species as outlined in the *Endangered Species Act* (50 CFR Part 402 and Part 200).

- Pretreatment and discharge requirements for waste water as outlined in the *Florida Industrial Waste Water Facilities* (Chapter 62-660), *Florida Water Quality Based Effluent Limitations* (Chapter 62-650) *Florida Pretreatment Requirements for Existing and New Sources of Pollution* (Chapter 62-625), and *Florida Waste Water Facility Permitting* (Chapter 62-620)

The FOTW is subject to NPDES requirements and FOTW effluent discharges must meet permit requirements

Balancing Criteria

Long-term Effectiveness and Permanence

Groundwater extraction would contain contaminants and reduce groundwater contamination by mass removal. Groundwater migration is expected to be arrested by the containment system. Alternative G5 reduces risk through mass removal and offers protection by containing the source. Furthermore, groundwater monitoring effectively assesses mass reduction and contaminant migration potential from areas not contained by groundwater extraction. A groundwater sampling and monitoring program will be developed after five pore volumes have been extracted.

Reduction of Toxicity, Mobility, or Volume Through Treatment

This alternative removes and contains contaminant mass. Groundwater removal at Sites 25, 27, and 30 would reduce groundwater toxicity, and contaminant volume. Groundwater containment eliminates contaminant migration. This alternative would reduce mobility or volume through mass removal. Over three years, Alternative G5 would extract an estimated 50 million gallons of groundwater from Sites 25, 27, and 30. Assuming no requirement for pretreatment, this water would be collected and discharged to the FOTW. Mass removal of chlorinated hydrocarbons and primary metals in the surficial aquifer is expected to be permanent.

Short-term Effectiveness

Adverse impacts to the surrounding environment are not anticipated during groundwater recovery system construction Approval to discharge to the FOTW needs to be obtained before implementation. After design plans are approved and testing is complete, the groundwater collection system would be constructed. Collection of five pore volumes is estimated to take three years.

Workers exposed to risks should be trained according to OSHA standards as required by 29 CFR 1910.120 to protect and mitigate risks during remedial construction. Field personnel contact with site contaminants would be minimal during construction (pump installation, control panel installation, and sanitary sewer connections). Worker protection could be managed through appropriate PPE. Compliance with RGs could be determined by monitoring site wells while system performance and mass removal could be evaluated by effluent monitoring. Alternative G5 would be compatible with any additional remedial actions, if required.

Implementability

Extracting contaminated groundwater beneath the site is both technically and administratively feasible. This alternative would not require any extraordinary services, materials, specialists, or innovative technologies. Construction and operation could be achieved with minimal difficulty. Implementation could begin immediately.

Cost

Direct and indirect costs associated with groundwater extraction Alternative G5 are $329,800. Annual operation, maintenance, and FOTW costs are expected to be $57,500 (including groundwater monitoring). The total present value cost of Alternative G5, including implementing institutional controls and the costs for the remedial action contractor, is estimated to be $583,500 (assuming a 6% discount rate over three years).

Modifying Criteria

State/Support Agency Acceptance

FDEP and the USEPA will have the opportunity to review and comment on this FS

Community Acceptance

These criteria are generally not completed until after public comments on the RI/FS report and the proposed plan are received

9.6.6 Alternative G6: Groundwater Extraction and Air Stripping with Inorganics Pretreatment

This alternative involves recovering groundwater by well extraction. Extracted groundwater would be treated onsite and discharged to the FOTW. The treatment technologies identified for groundwater are chemical/physical processes for chlorinated hydrocarbons and primary and secondary heavy metals. Area remediation would remove a potential source of downgradient contamination, and permit natural flushing and attenuation of contaminant plumes. Three treatment systems have been evaluated — air stripping with a pretreatment unit:

(a) coagulation/precipitation, (b) membrane filtration, and (c) ion exchange. This alternative also includes institutional controls for PQG RGs.

Threshold Criteria

Overall Protection of Human Health and the Environment

Human health is protected by extracting, containing, and treating contaminated groundwater in which contaminants exceed PQG criteria for chlorinated hydrocarbons and heavy metals, thus preventing contaminant migration beyond the source area and removing mass in contaminated zones. Extracted groundwater would be treated before discharge to the FOTW Institutional controls would limit groundwater use.

Compliance with ARARs

Groundwater extraction and treatment complies with the chemical-specific ARARs developed in Section 9 1 Florida Proposed Rule 62-777 is also a potential ARAR for OU 2. ARARs that identify alternative cleanup target levels based on poor quality groundwater include Florida Rules 62-770, 62-781, and 62-785. The contaminated groundwater would be captured by extraction wells and treated, thus removing contaminants that exceed PQG criteria. Groundwater removal from Sites 25, 27, and 30 is intended to reduce contaminants mass in the aquifer and contain two groundwater areas of concern. The FOTW is subject to NPDES requirements and all FOTW effluent must meet these requirements

Waste disposal standards for waste generated from the treatment system would be triggered; specific waste disposal ARARs depend on sludge characteristics. Both federal and Florida action-specific ARARs would be met by Alternative G6. Hazardous materials might be treated or stored onsite as a result of remedial activity and proper management of these materials in accordance with Florida Hazardous Waste Rules would be required. Location- and action-specific ARARs include the following

- Floodplain requirements as outlined in the *National Environmental Policy Act* (40 CFR Part 6, Appendix A).

- Requirements for wetland endangered species as outlined in the *Endangered Species Act* (50 CFR Part 402 and Part 200).

- Treatment residuals requirements as outlined in the *RCRA Identification of Hazardous Waste* (40 CFR 261), *RCRA Generator Standards* (40 CFR 262), *RCRA Facility Standards* (40 CFR 264), *RCRA Land Disposal Restrictions* (40 CFR 268), *DOT Rules for the Transport of Hazardous Substances* (49 CFR Parts 107 and 171-179), and *Florida Hazardous Waste Rules* (Chapter 62-730)

- Requirements for air emissions as outlined in the *Clean Air Act Permits Regulation* (40 CFR 72) and *Florida Air Pollution Rules* (Chapters 62-210, 62-212, 62-213, and 62-296)

- Discharge and pretreatment requirements as outlined in the *Clean Water Act General Pretreatment regulations for Existing and New Sources of Pollution* (40 CFR 403), *Florida Industrial Waste Water Facilities* (Chapter 62-660), *Florida Water Quality Based Effluent Limitations* (Chapter 62-650), *Florida Pretreatment Requirements for Existing and New Sources of Pollution* (Chapter 62-625), *Florida Waste Water Facility Permitting* (Chapter 62-620)

The FOTW is subject to NPDES requirements and all FOTW effluent must meet these requirements.

Balancing Criteria

Long-term Effectiveness and Permanence

Groundwater extraction and treatment would contain contaminants and reduce chlorinated hydrocarbon and heavy metals concentrations through mass removal. Groundwater migration is expected to be arrested by the containment system. Groundwater extraction removes contaminants from the surficial zone and contains plume areas. This alternative effectively removes contaminant mass. Ex situ groundwater treatment removes contaminants. Furthermore, groundwater monitoring effectively assesses mass reduction and contaminant migration potential from areas not contained by groundwater extraction. A groundwater sampling and monitoring program will be developed after five pore volumes have been extracted.

Reduction of Toxicity, Mobility, or Volume Through Treatment

This alternative removes/contains mass Groundwater removal at Sites 25, 27, and 30 would reduce its toxicity and reduce the contaminant volume.

Air stripping and the proposed chemical and physical treatment units are established technologies for removing contaminants. Inorganic compounds (primary and secondary metals) would be separated in a sludge or concentrated liquid and disposed of offsite. Groundwater containment eliminates contaminant migration. This alternative reduces toxicity, mobility, or volume through treatment, and satisfies the statutory preference for treatment as a principal element. Additional treatment is also provided by the FOTW.

Over three years, Alternative G6 would extract an estimated 50 million gallons of groundwater, which would be collected and discharged to the FOTW. Flow-rate estimates, based on preliminary modeling, are 7.5 gpm for each of the two wells. Contaminant mass removal in the surficial aquifer is expected to be permanent.

Short-term Effectiveness

Adverse impacts to the surrounding environment are not anticipated during groundwater recovery and treatment system construction. The FOTW needs to accept discharge before implementation. After design plans are approved and testing is complete, the groundwater collection system would be constructed. Collection of five pore volumes would probably take three years.

Field personnel contact with site contaminants would be minimal during construction (pump installation, control panel installation, and sanitary sewer connections.) Worker protection could be managed through use of appropriate PPE and a HASP implementation.

RG compliance could be determined by monitoring site wells while system performance and mass removal could be evaluated by effluent monitoring Alternative G6 would be compatible with any additional remedial actions, if required

Implementability

Extracting contaminated groundwater from beneath the site and providing treatment is both technically and administratively feasible. This alternative would not require any extraordinary services, materials, specialists, or innovative technologies. Construction and operation could be achieved with minimal difficulty. Offsite disposal would be required for solids or concentrated liquids generated by ether arsenic treatment process. Implementation could begin immediately.

Cost

Costs are discussed in two groups: (1) groundwater recovery and (2) groundwater treatment:

- *Alternative G6 Groundwater Recovery:* Direct and indirect costs associated with groundwater extraction for Alterative G6a, G6b, and G6c are $329,800 (includes institutional controls, aquifer testing, and FOTW cooperation). Annual maintenance costs are expected to be $57,500.

- *Alternative G6a: Air Stripping with Coagulation/Precipitation:* Direct and indirect capital costs for air stripping and physical/chemical treatment for Alterative G6a are $1,389,400. Annual operating costs for treatment are expected to be $228,000; annual disposal costs are estimated to be $23,200. The total present value of air stripping with coagulation/precipitation is $2,060,800 — $2,644,300 including groundwater recovery (assuming a 6% discount rate over three years).

- *Alternative G6b: Air Stripping with Membrane Filtration:* Direct and indirect capital costs for air stripping and physical/chemical treatment for Alterative G6b are $729,500. Annual operating costs for treatment are expected to be $158,000; annual disposal costs are estimated to be $23,200 The total present value of air stripping with membrane filtration is $1,213,800 — $1,797,300 including groundwater recovery (assuming a 6% discount rate over three years).

- *Alternative G6c: Air Stripping with Ion Exchange:* Direct and indirect capital costs for air stripping and physical/chemical treatment for Alterative G6c are $816,500. Annual operating costs for treatment are expected to be $163,000; annual disposal costs are estimated to be $72,500. The total present value of air stripping with membrane filtration is $1,446,000 — $2,029,500 including groundwater recovery (assuming a 6% discount rate over three years)

Modifying Criteria

State/Support Agency Acceptance

FDEP and the USEPA will have the opportunity to review and comment on this FS.

Community Acceptance

These criteria are generally not completed until after public comments on the RI/FS report and the proposed plan are received.

9.7 Comparative Analysis of Alternatives

A comparative analysis of the five groundwater remedial alternatives, based on the nine criteria, is summarized in Table 9-21

Table 9-21
Comparative Analysis of Groundwater Alternatives

Evaluation Criteria	Alternative G1	Alternative G2	Alternative G3	Alternative G4	Alternative G5	Alternative G6
Threshold Criteria						
Protection of human health and the environment (HH&E)	No action is implemented to protect HH&E. Without action, current conditions are not protective.	Restrictions on groundwater use and attenuation of contaminant concentrations will protect HH&E.	Protects HH&E by slowly removing, transforming, or immobilizing contaminants in the groundwater.	Protects HH&E by slowly removing, transforming, or immobilizing contaminants in the groundwater.	Protects HH&E through groundwater containment and removal.	Protects HH&E through groundwater containment, removal, and treatment.
Compliance with ARARs	Does not comply with ARARs	Exceedances are monitored to ensure compliance over time.	Exceedances are monitored to ensure compliance over time	Complies with ARARs through in situ treatment.	Complies with ARARs through mass removal.	Complies with ARARs through mass removal and treatment.
Balancing Criteria						
Long-term effectiveness and permanence	None.	Attenuation is a slow process — therefore, long-term effectiveness may be minimal.	Limited to research activities and limited field testing	Groundwater contaminant migration is expected to be arrested and destroyed by the containment system.	Groundwater contaminant migration is expected to be arrested by the containment system	Groundwater contaminant migration is expected to be arrested by the containment system. Treatment is expected to destroy contaminants
Reduction of toxicity, mobility, or volume through treatment	None.	Toxicity, mobility, and volume are reduced via natural processes.	Toxicity, mobility, and volume are reduced via degradation or immobilization.	Toxicity, mobility, and volume are reduced via degradation or immobilization.	Reduces toxicity, mobility, and volume through mass removal.	Reduces toxicity, mobility, and volume through mass removal and treatment.
Short-term effectiveness	No risks are associated with no-action.	No risks are associated with MNA.	Groundwater restrictions, institutional and engineering controls, and a site-specific HASP will provide short-term effectiveness.	Minimal risks are associated with this in situ remedial alternative.	Adverse impacts to surrounding environment are not anticipated during groundwater recovery system construction.	Adverse impacts to surrounding environment are not anticipated during groundwater recovery system construction
Implementability	Technically and administratively feasible. Easily implemented.	Technically and administratively feasible. Easily implemented.	Technically and administratively feasible. Easy to install, maintain, and monitor.	Technically and administratively feasible. Preliminary hydrogeological and geochemistry investigation might be required.	Technically and administratively feasible. Requires routine system O&M.	Technically and administratively feasible. Requires routine system O&M. Offsite disposal of sludge required.

Table 9-21
Comparative Analysis of Groundwater Alternatives

Evaluation Criteria	Alternative G1	Alternative G2	Alternative G3	Alternative G4	Alternative G5	Alternative G6
Cost	Capital: none Annual: $48,100 (every five years) PW: $117,500	Capital: $313,600 Annual: $65,900 PW: $1,320,700	Capital: $268,300 Annual: $82,900 PW: $1,509,400	Capital: $742,500 Annual: $39,100 PW: $1,380,700	Capital: $329,800 Annual: $94,500 PW: $682,400	Capital: $1,059,300 to $1,718,300 Annual: $286,600 to $395,000 PW: $1,925,300 to $2,637,800
Modifying Criteria						
State/Support Agency Acceptance	FDEP and USEPA will have opportunity to review and comment on technology	FDEP and USEPA will have opportunity to review and comment on technology	FDEP and USEPA will have opportunity to review and comment on technology	FDEP and USEPA will have opportunity to review and comment on technology	FDEP and USEPA will have opportunity to review and comment on technology.	FDEP and USEPA will have opportunity to review and comment on technology.
Community Acceptance	Community acceptance would be established after comment period.	Community acceptance will be determined after the public comment period. Public education on the difference between no-action and MNA may be required.	Community acceptance would be established after comment period.	Community acceptance would be established after comment period.	Community acceptance would be established after comment period.	Community acceptance would be established after comment period.

Notes:

Alternative G1	=	No-action
Alternative G2	=	Monitored natural attenuation
Alternative G3	=	Phytoremediation
Alternative G4	=	Permeable Reactive Barrier
Alternative G5	=	Groundwater extraction and disposal to the FOTW
Alternative G6	=	Groundwater extraction and air stripping with inorganics pretreatment
PW	=	present worth

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